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Estimation of Retention Parameters for the Prototype Officer Personnel Inventory, Cost and Compensation Model

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United States Army Research Institute
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This research estimated a multiperiod Annualized Cost of Leaving (ACOL-2) model that predicts officer career decisions as a function of economic, demographic, and Army personnel policy (e.g., military compensation) influences. The panel probit estimation yielded statistically significant pay but not unemployment effects. The research also found that fixed, unobserved preferences for military service significantly influence retention behavior. The estimation encompassed up to 13 consecutive annual "decision" points, with data taken from ARI's Officer Longitudinal Research Database, covering year groups 1979-1992. The retention parameter estimates were embedded in an Officer Personnel Inventory, Cost and Compensation (OPICC) Model. This PC-based prototype model was designed and developed to improve the Army's ability to effectively manage its officer force by providing policy makers with accurate information about the impact of policy changes, including promotion policy, compensation, and separation incentives. The OPICC model provides estimates of the impacts of policy and economic changes to the Officer Personnel Management Directorate inventory for a 6-year projection horizon. The prototype version does not contain a cost estimation capability. The model was validated by using it to predict actual historical behavior.

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Estimation of Retention Parameters for the Prototype Officer Personnel Inventory, Cost and Compensation Model

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Foreword

The Manpower and Personnel Policy Research Team at the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research on the economics of manpower and personnel issues of particular significance to the U.S. Army. This project developed and estimated a multiperiod Annualized Cost of Leaving (ACOL-2) econometric model of the retention decision of field-grade, active-duty officers in the Officer Personnel Management Directorate Branches. This research expanded on a previous project that estimated the ACOL-2 model for officers in the Infantry and Signal Corps branches. The econometric estimation was conducted to provide parameters for the prototype Officer Personnel Inventory, Cost and Compensation (OPICC) model.

ARI's participation in this effort is part of an ongoing program of research designed to enhance the quality of Army officer personnel. This work is an essential part of the mission to conduct research to improve the Army's ability to effectively and efficiently manage the force.

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ESTIMATION OF RETENTION PARAMETERS FOR THE PROTOTYPE OFFICER PERSONNEL INVENTORY, COST AND COMPENSATION MODEL

EXECUTIVE SUMMARY

Research Requirement:

Information about the manpower costs and effects of personnel policy and other factors on the retention of high-quality active-duty commissioned officers, both for the aggregate Army and at the branch level, is critical to the development of the human resources necessary for an effective officer force. Indeed, the U.S. Army must be able to measure the effects of personnel policy options and changes on the size, shape, and cost of its officer force. An Officer Personnel Inventory, Cost and Compensation (OPICC) model would improve the Army's ability to effectively and efficiently manage the officer force. It would provide policy makers with timely and accurate information about the impact of policy changes, including promotion policy, compensation, and separation incentives. This type of model would also project the size and skill composition of the officer force and would estimate the cost of manpower to the Army. The model would contain econometric estimates that quantify officer responsiveness to compensation policy and labor market conditions.

Procedure:

This research extends and expands upon previous work by specifying and estimating a multiperiod Annualized Cost of Leaving (ACOL-2) model for officers, and by designing, building, and testing a PC-based prototype officer policy analysis model. ACOL-2 is a dynamic structural econometric model of the decision to stay in or leave the military as an occupation. It represents a more realistic portrayal of retention behavior and was estimated for officers in the Officer Personnel Management Directorate (OPMD) branches over the 1979-1992 period. The estimated retention parameters function as the engine for the prototype OPICC model.

Findings:

A multiperiod model that predicts officer career decisions as a function of economic, demographic, and Army personnel policy (e.g., Military compensation) factors was successfully estimated with longitudinal data from the U.S. Army Research Institute for the Behavioral and Social Sciences' (ARI) Officer Longitudinal Research Database (OLRDB). The model estimates yielded highly (statistically) significant pay effects in the expected directions, but did not reveal a significant effect for changes

in unemployment. The research findings did demonstrate that fixed, unobserved preferences for Army service exert a great deal of influence on observed retention behavior. The model specification in this research extended the portion of an officer's career observed through the end of YOS 15.

The prototype OPICC model (except for the cost module) is fully operational and provides ready estimates of the inventory and retention impacts of policy, economic, and institutional changes on the OPMD officer force. The model was successfully validated in several exercises by using it to predict historical behavior (from a prior baseline) in the OPMD officer force and then comparing the projected results to actual behavior.

Utilization of Findings:

This research has resulted in a useful policy tool designed to assist Army personnel analysts and decision makers in predicting the impact of changes in compensation, career paths, and force requirements on officer behavior.

ESTIMATION OF RETENTION PARAMETERS FOR THE PROTOTYPE OFFICER PERSONNEL INVENTORY, COST AND COMPENSATION MODEL

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ESTIMATION OF RETENTION PARAMETERS FOR THE PROTOTYPE OFFICER PERSONNEL INVENTORY, COST AND COMPENSATION MODEL

INTRODUCTION

This research provides the Army with a reliable policy-analysis tool capable of measuring the impact of changes in compensation, personnel and manpower policies on its Officer Personnel Management Directorate (OPMD) officer community. In addition to developing a Markov-process inventory projection model, it includes new estimates of the behavioral retention effects of changes in pay, personnel policy and civilian-sector economic conditions. The OPICC model is PC-based and provides rapid-response analytical capability to Army analysts.

Several recent developments accentuate the need for OPICC. The Army faces an unprecedented task as it undertakes its first significant downsizing under the All-Volunteer Force. A variety of policy actions have been implemented or are being considered to facilitate the downsizing. These include separation incentives, fifteen-year retirement and tighter promotion rules. Moreover, the Army must assess such policy changes in the context of parallel changes in the civilian labor market.

This report summarizes the research completed. It focuses primarily on the econometric research, but includes a discussion of the structure and methodology of the OPICC model as well. For a detailed description of OPICC, refer to the OPICC User Manual.

THEORY

Behavioral retention models estimate the effects of pay changes and economic conditions on the propensity of individuals to remain in the military. These models are grounded in the economics literature on occupational choice. Most military retention studies assume a two-choice world in which an individual may choose employment in the military or employment in civilian occupations.

A crucial issue which retention models must address is the horizon problem. That is, over what horizon should two occupational alternatives be compared? This issue is especially important because of the influence of the retirement system. If a member completes 20 years of active duty service, he or she is eligible for an immediate, substantial annuity upon leaving service. However, in the general case, no annuity is received if the member leaves with fewer than twenty years of service. Whether or not a member's decision horizon is assumed to incorporate the twenty years of service point has a substantial effect on the measured incentive to stay in service.

The Annualized Cost of Leaving (ACOL) model provides a consistent, non-arbitrary solution to this question: the horizon is chosen for which the annual difference between military and civilian pay is largest. If the individual will not stay for this horizon, he or she will not stay for any horizon that implies a less generous rate of military pay relative to civilian alternatives. There are other models that dynamically consider multiple horizons simultaneously in a rational way, but they are less tractable both in estimation and in application to policy.

Retention models must also account for changes in cohort behavior over time. Cohort retention rates rise with tenure for two principal reasons.[1] First, officers accumulate firm-specific human capital with tenure. This capital has no value to other employers; the employee would forfeit it upon quitting. Retention rates also rise with tenure simply because those who have a relatively high "taste" for Army life will tend to stay at higher rates than those who do not. That is, the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. This phenomenon is referred to as "taste censoring" or "unobserved heterogeneity" in the econometrics literature.

This section summarizes the utility-maximization model of retention decisions faced by Army officers used in this research. It begins with a brief survey of related studies and discusses the application of this approach to the retention decision of OPMD Army officers. Finally, the section describes the construction of the key explanatory variable: the Annualized Cost of Leaving (ACOL).

Review of the Literature

Research on retention in the Department of Defense is currently at the frontiers of economic models of occupational choice. However, there has been less research conducted on officer retention behavior than enlisted retention. Three models are prominent: the Annualized Cost of Leaving (ACOL) model; the ACOL-2 model, which is estimated as a panel probit and explicitly controls self-selection as members progress through the personnel system; and the Dynamic Retention Model (DRM) developed by Gotz and McCall (1983).

---

[1]In the case of military service, a third reason for increases in tenure with years of service is the nature of the retirement system, which provides an increasingly powerful incentive to stay through twenty years of service, as the twenty year point is approached. Clearly, part of the retirement incentive is to encourage the retention of members who have accumulated significant firm-specific capital. However, it undoubtedly provides an incentive that is greater than can be explained solely as compensation for the accumulation of firm-specific capital.

The simple ACOL model has been estimated for enlisted retention behavior in the Navy (Warner and Goldberg (1984)) and for each of the military Services in the aggregate (Enns, Nelson and Warner (1984)). Hogan and Goon (1989) also estimated a version for Air Force officers. The Gotz-McCall model was originally estimated for Air Force captains. Gotz and McCall (1983) provide the theory. The estimated parameters of the model were not published, however. It was later "calibrated" for Air Force enlisted personnel by Arguden (1986). The ACOL-2 model was estimated for both Navy and Army enlisted personnel (Black, Hogan and Sylwester (1987) and Smith, Sylwester and Villa (1991)). It was estimated for DoD civilians by Black, Moffitt and Warner (1990).

Mairs, *et. al.* (1992) were the first to estimate an ACOL-2 model for the officer force. This effort also constituted one of the few attempts to estimate a retention model for Army officers. They estimated a retention model for the Air Defense Artillery branch. The model, which suggested that econometric models of Army officer retention behavior were feasible and had potential relevance to policy decisions, had two shortcomings. First, the crucial initial decision point for officer retention, the end of the initial service obligation, had to be inferred from the officer's source of commission. While this inference was valid for a large majority of the observations, error was undoubtedly introduced in some cases. Second, the model was estimated as a bivariate probit model. Hence, only two decision points could be analyzed.[2]

Mackin, Hogan and Mairs (1993) extended this analysis of Army officer retention behavior. Their research developed a multi-period model of Army officer retention behavior and estimated it for Infantry and Signal Corps officers. Officers were observed for up to eleven consecutive retention decisions.

Each method has strengths and weaknesses. The ACOL-2 model and the Gotz-McCall model explicitly control for unobserved heterogeneity—the self-selection that occurs as retention rates rise with tenure. Failure to control for unobserved differences

[2]In addition, as a consequence of both (a) potential error in distinguishing the end of the initial term of obligated service and (b) the limit of two decision points, the time period for calculating the hazard rate was lengthened from the traditional one-year retention rate to a three-year period. This makes it difficult to compare the results directly with other results in the literature, and potentially introduces additional measurement error, since the explanatory variables are measured at the mean of the period over which the hazard is computed.

may lead to biased parameter estimates.[3] The ACOL-2 model is easier to estimate and use in policy simulations than the Gotz-McCall model. This research estimates an ACOL-2 model for OPMD Army officers, building on previous research that examined the Air Defense Artillery (ADA), Infantry(IN) and Signal Corps (SC) branches.[4] The model has also been expanded to consider retention decisions through the fifteenth year of service.

Economic Model of Occupational Choice

Economic models of retention behavior assume that individuals seek to maximize utility by choosing either to stay in the Army or leave for the civilian sector. Utility, in turn, depends on pecuniary and non-pecuniary factors. Pecuniary influences consist of military pay and civilian earnings opportunities. Non-pecuniary factors include preference for military service; hardship associated with a duty station; and family separation.

Models of occupational choice predict that an individual chooses a career path to maximize the present value of future potential returns across his/her entire working life. In the Army officer retention model, this framework compares an officer's expected time path of pecuniary and non-pecuniary returns if he/she stays in the Army to the corresponding expected time path of returns to leaving immediately. The ACOL model attempts to measure these effects quantitatively as the annualized net benefit of staying in the military.

Individual Utility Maximization. Economic models of occupational choice applied to military retention decisions assume that individuals rank jobs based on the pecuniary and non-pecuniary aspects of those jobs, and choose a job, or time path of jobs, that provides the greatest satisfaction or utility over the individual's lifetime.[5]

---

[3]Hogan and Goon (1989) estimated a version of the simpler ACOL model for Air Force officers by occupational specialty, using other variables to control for censoring in the error structure, and found that these variables worked well.

[4]The Procurement Program Number (PPN) code, which indicates the program under which the officer entered the Army, and the initial obligation incurred because of that program, has been added to the Officer Longitudinal Data Base (OLRDB), reducing errors in determining initial obligation.

[5]See, for example, Smith, *et. al.* (1991); Black, Hogan, and Sylwester (1987); Hogan and Goon (1989); and, for a review of current methods and research issues, Hogan and Black (1991).

The utility function that describes the individual's preferences (or values) for various job characteristics typically includes measures of current and expected future military and civilian pay and measures describing the value of non-pecuniary conditions of military service (e.g., rotation frequency, hours of work). The value of the i^{th} attribute of an Army job is represented by $X_{i,A}$ and the value of the i^{th} attribute of the best civilian career opportunity is represented by $X_{i,C}$. According to this model, an individual reenlists if:

$$U(X_{1,A},\ldots,X_{n,A}) > U(X_{1,C},\ldots,X_{n,C}) \ . \tag{1}$$

Random Utility Model. The function U(...) is not, of course, known to the researcher, nor are all the factors that affect a member's decision known and measurable by the researcher. One popular empirical formulation that makes assumptions concerning this "ignorance" and incorporates it into the model is the "random utility" model. An assumption concerning an explicit functional form of the utility function is made, along with an assumption concerning an unobservable random component. For example, a linear utility function results in the following model:

Individual j will stay if and only if:

$$X_{j,A}\beta + \gamma_{j,A} > X_{j,C}\beta + \gamma_{j,C} \tag{2}$$

or

$$(X_{j,A} - X_{j,C})\beta > \gamma_{j,C} - \gamma_{j,A} \ . \tag{3}$$

where $X_{j,A}$ is a vector of characteristics associated with an Army job and $X_{j,C}$ is a vector of characteristics associated with the best civilian alternative; β is a vector of coefficients to be estimated and the γs represent unobservable (to the researcher) aspects of the utility or satisfaction associated with Army and civilian alternatives. This difference, $\gamma_{j,C} - \gamma_{j,A}$, is represented by the variable γ_j, which is distributed over the population of potential stayers according to $f(\gamma)$.[6] Then, the probability that individual j stays is:

$$\text{Prob}\left[(X_{j,A} - X_{j,C})\beta > \gamma_j\right] = \int_{-\infty}^{(X_{j,A}-X_{j,C})\beta} f(\gamma)\,d\gamma \ . \tag{4}$$

If γ is distributed $N(0,\sigma_\gamma)$, then

[6]Note that individual characteristics, assumed to be correlated with an individual's taste for various job attributes, can be included in the model, presumably reducing the dispersion of the unobserved component.

$$\text{Prob}\left[(X_{j,A} - X_{j,C})\beta > \gamma_j\right] = \int_{-\infty}^{(X_{j,A}-X_{j,C})\beta/\sigma} f'(\gamma')\,d\gamma' . \tag{5}$$

where γ' is a standard normal random variable. This model can be estimated as a probit.

<u>ACOL Model</u>. The Annualized Cost of Leaving Model (ACOL) is derived from this random utility framework simply by specifying that the individual considers the entire future time path of military and civilian income in a rational way. In particular, the differences in the *X*s representing military and civilian pay are replaced by the annualized, or annuitized, difference of the present value of these variables calculated over a horizon which maximizes the annualized difference. The decision rule becomes, stay at time *t* if and only if

$$ACOL_{j,t} + Z_{j,t}\beta > \gamma_{j,t} , \tag{6}$$

where $Z_{j,t}$ represents the net difference between other Army job and civilian alternative characteristics $(X_A - X_C)$.

<u>ACOL-2 (Panel Probit) Formulation</u>. The empirical definition of the simple ACOL model, derived above, does not account for unobserved heterogeneity. Because retention rates rise with tenure (see the discussion above), the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. The simple ACOL model does not capture this change. Consequently, if measured factors are correlated with this changing distribution of unobserved factors, the coefficients in the ACOL model are potentially biased.

The ACOL-2 (panel probit) formulation follows directly from this framework when one explicitly provides greater structure to the unobserved component of the decision rule, $\gamma_{j,t}$. In particular, let this error term consist of two parts. The first is an individual-specific, permanent component, α_j, while the second is a transitory component, $\epsilon_{j,t}$:

$$\gamma_{j,t} = \alpha_j + \epsilon_{j,t} . \tag{7}$$

The decision rule, ignoring *Z*, becomes stay if and only if:

$$ACOL_{j,t} - \alpha_j > \epsilon_{j,t}. \tag{8}$$

Now, include the *Z* characteristics affecting the decision to stay, such that:

$$X_{j,t}\delta = (ACOL_{j,t}, Z_{j,t})(1, \beta). \tag{9}$$

Following the decision rule, the probability that an individual

will stay is:

$$\text{Prob}\left[X_{j,t}\boldsymbol{\delta} - \boldsymbol{\alpha}_j > \epsilon_{j,t}\right] = \int_{-\infty}^{(X_{j,t}\boldsymbol{\delta}-\boldsymbol{\alpha}_j)} f(\epsilon_{j,t})\,d\epsilon_{j,t} \ . \tag{10}$$

With ϵ distributed normally with mean zero and standard deviation σ_ϵ, the probability that the individual stays in period *t*, given that the individual has stayed through period *t - 1*, is given by

$$\int_{-\infty}^{(X_{j,t}\boldsymbol{\delta}-\boldsymbol{\alpha}_j)} f(\epsilon_{j,t})\,d\epsilon_{j,t} = F\left[\frac{X_{j,t}\boldsymbol{\delta}-\boldsymbol{\alpha}_j}{\boldsymbol{\sigma}_\epsilon}\right], \tag{11}$$

where *F(...)* is the cumulative distribution function of the standard normal random variable.[7] Then, the probability that an individual enters at t = 1, stays through T - 1 periods, and leaves in period T, is given by:

$$Q_T = \prod_{t=1}^{T-1}\left(F\left[\frac{X_{j,t}\boldsymbol{\delta}-\boldsymbol{\alpha}_j}{\boldsymbol{\sigma}_\epsilon}\right]\right) \cdot F\left[\frac{-(X_{j,T}\boldsymbol{\delta} - \boldsymbol{\alpha}_j)}{\boldsymbol{\sigma}_\epsilon}\right], \tag{12}$$

where Q_T is the probability that an individual who enters at t = 1 leaves in period T.

This is a one-factor, variance-components formulation, which has the following interpretation. When an officer arrives at a decision point, it is as if he/she draws an $\epsilon_{j,t}$ at random from a distribution with mean zero. This distribution is the same for all officers. Moreover, if the officer stays and comes to another decision point, he/she again draws randomly from the distribution $f(\epsilon_{j,t})$. This value will be uncorrelated with the previous draw. In addition, the officer has a "permanent" component, $\boldsymbol{\alpha}_j$, that remains constant across decision points. This component is distributed over all officers according to the density function $f'(\boldsymbol{\alpha})$, which is also assumed to be normal. An officer cohort's distribution of $\boldsymbol{\alpha}$'s changes as officers pass through multiple decision points. Those with relatively greater preferences for Army service (higher $\boldsymbol{\alpha}$'s) will tend to stay at higher rates, so that the distribution of $\boldsymbol{\alpha}$'s for the remaining officers is censored.

For a cohort of officers who enter at period 1, the proportion who stay through period T-1, and then leave at T, is:

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T-1}\left(F\left[\frac{X_{j,t}\boldsymbol{\delta}-\boldsymbol{\alpha}_j}{\boldsymbol{\sigma}_\epsilon}\right]\right) \cdot F\left[\frac{-(X_{j,T}\boldsymbol{\delta} - \boldsymbol{\alpha}_j)}{\boldsymbol{\sigma}_\epsilon}\right] f'(\boldsymbol{\alpha}_j)\,d\boldsymbol{\alpha}_j \ . \tag{13}$$

---

[7]Note that 1-F[-C]=F[C], by the symmetry of the standard normal distribution.

where $f'(\alpha)$ is the density function of α, with mean u_α. Now, if α and ϵ are independent, then

$$\sigma^2_\gamma = \sigma^2_\epsilon + \sigma^2_\alpha . \tag{14}$$

Define the parameter:

$$\rho = \frac{\sigma^2_\alpha}{\sigma^2_\alpha + \sigma^2_\epsilon} = \frac{\sigma^2_\alpha}{\sigma^2_\gamma} . \tag{15}$$

This parameter represents the correlation in the total disturbance term between successive time periods. Assuming that the transitory component of the error term, ϵ, is uncorrelated over time, this term represents the importance of the fixed component of "tastes," α, in explaining the pattern of retention rates over time. Also, define $g_j = (\alpha_j - u_\alpha)/\sigma_\alpha$, implying that $\alpha_j = u_\alpha + \sigma_\alpha g_j$.

Next, note that[8]

$$\sigma_\epsilon = \sigma_\gamma (1-\rho)^{1/2} \; ; \; \frac{\sigma_\alpha}{\sigma_\epsilon} = \left[\frac{\rho}{(1-\rho)}\right]^{1/2} . \tag{16}$$

Let the expression for the ratio of the standard deviation in the permanent component of the error to the standard deviation in the transitory component be denoted by r. Further, let $y_{j,t} = 1$ for those who stay in period t, and $y_{j,t} = 0$ for those who leave in period t. The expression for the cohort survival rate to time T can now be rewritten as

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{X_{j,t}\delta - u_\alpha}{\sigma_\gamma (1-\rho)^{1/2}} - rg_j\right](2y_{j,t}-1) f'(\alpha_j) d\alpha_j . \tag{17}$$

Making additional substitutions for $f'(\alpha)$, one obtains

[8] To see this result, recall that

$$\rho = \frac{\sigma^2_\alpha}{(\sigma^2_\alpha + \sigma^2_\epsilon)} .$$

Solving this equation obtains the expression for $\sigma_\alpha/\sigma_\epsilon$. Also, one can rewrite the expression:

$$\rho = \frac{\sigma^2_\gamma - \sigma^2_\epsilon}{\sigma^2_\gamma} .$$

Solving this expression for σ_ϵ obtains the expression in the text.

$$Q_T=\int_{-\infty}^{\infty}\prod_{t=1}^{T}F\left[\frac{X_{j,t}\delta-u_{\alpha}}{\sigma_{\gamma}(1-\rho)^{1/2}}-rg_j\right](2y_{j,t}-1)\frac{1}{(2\pi)^{1/2}}\exp^{-g_j^2/2}dg_j\ . \qquad (18)$$

The variable ρ measures the proportion of the variance in the error that is accounted for by individual-specific factors affecting retention rates (α). If it is positive, retention rates will tend to rise simply as a result of the sorting process, with those having a low "taste" for military life selecting themselves out at early decision points. The coefficient on the ACOL variable is equal to $1/(\sigma_{\gamma}(1-\rho)^{1/2})$. Hence, officers will be more responsive to pay differences (a) the lower the dispersion or variance in unmeasured factors, σ_{γ}, and (b) the greater is the systematic component of unobserved factors affecting officer retention (*i.e.*, the greater is ρ).

Calculation of the ACOL Variable

The most important explanatory variable in the model is the return to the occupation, or earnings. In theory, ACOL equals the difference between expected military earnings and alternative civilian earnings (M - C) and the value of the non-pecuniary factors affecting retention, including the "taste" component. For the estimation model, however, tastes appear implicitly in the error term. Thus, the ACOL variable used here includes two elements: military and civilian earnings.

The economic theory of human capital implies that individuals choose a course of action that maximizes the net present value of returns over their remaining working lives. This concept has implications for determining the appropriate horizon for considering a job change. In other words, an individual will not change jobs to achieve a higher immediate wage if the net present value of returns over his/her lifetime is lowered, holding non-pecuniary differences constant.

The model is normalized by expressing returns as the difference between the returns to staying in the military and the returns to leaving immediately (hence, the "cost of leaving"). The pay variable is the difference between expected lifetime earnings if the individual stays until some optimal horizon and expected earnings if he/she leaves immediately. The determination of optimal horizon is discussed below.

The ACOL model is sometimes referred to as a "maximum regret" model.[9] It assumes that an individual will leave immediately only if $M_j-C_j < -Z\beta + \alpha_j + \epsilon_{j,t}$ for each j = 1,2,...,30

[9]Arguden (1986), p. 30.

- YOS. This implies that an officer will stay if there is at least one horizon for which the returns to staying exceed the returns to leaving. The ACOL variable is defined as the maximum pay difference over all possible horizons.[10]

To calculate the ACOL variable, assume that an officer can stay in the military for a maximum of *n* more years, and will stay in the labor force *T* more years, regardless of when he/she leaves the Army.[11] Then, calculate the following variables for *n* possible horizons:

1. M_k = expected military pay in year k (k=1,2,...,n).

2. W_{k0} = future potential civilian earnings from leaving immediately (k=1,2,...,T).

3. W_{kn} = future potential civilian earnings from staying *n* more years, where civilian wages are conditional on *n* years of military experience (k=n+1,n+2,...,T).

4. r = the personal discount rate.

5. $d^k = (1/(1+r))^k \quad (k=1,...,T)$.

The *cost of leaving* (C_n) is the discounted stream of pay differences over the *T*-year horizon:

$$C_n=\sum_{k=1}^{n} M_k d^k+\sum_{k=n+1}^{T} W_{kn} d^k-\sum_{k=1}^{T} W_{k0} d^k. \tag{19}$$

Rearranging terms,

$$C_n=\sum_{k=1}^{n} d^k (M_k-W_{k0})+\sum_{k=n+1}^{T} d^k (W_{kn}-W_{k0}). \tag{20}$$

This specification is valid for a generic specification of civilian earnings. The model that predicts civilian earnings in this research does not distinguish military from civilian experience in predicting future civilian earnings. Thus, W_{k0} = W_{kn} and the last term drops out:

$$C_n = \sum_{k=1}^{n} d^k (M_k-W_{k0}). \tag{21}$$

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[10]Warner and Goldberg (1984), pp. 14-15. Note that the ACOL measure should be considered an index describing the financial incentive to stay at least one more year. The horizon associated with the maximum ACOL value is not necessarily the optimal leaving point.

[11]This specification of the pay variable is derived from Warner and Goldberg (1984), p. 27.

Finally, the pay variable must account for the fact that the present value of pay received decreases with distance from the decision point. Thus, the annualized pay difference (A_n) is expressed as:

$$A_n = \frac{C_n}{\sum_{k=1}^{n} d^k}. \qquad (22)$$

The ACOL value used in the estimation is

$$\max_n A_n = A_n^*. \qquad (23)$$

where the horizon, n, maximizes the annuitized difference between military and civilian pay.

ECONOMETRIC MODEL

The model estimated for this research was an "all-Army" model in that it incorporated all officer branches in the OPMD Army population. Several key specification issues arose in the all-Army model, including:

- Cross-branch effects in the specification
- Decisions points beyond year of service 11
- Civilian earnings equation

This section begins with the specification of the econometric retention model within an ACOL-2 framework. The remainder of the section discusses the three specification issues listed here.

Estimation Model

This model of officer voluntary stay-leave decisions includes multiple decision points for all officers. A decision point, for which a retention or hazard rate is estimated, is a year-long interval over which the officer is assumed to be free to leave the Army, should he or she choose to do so. The first decision point is the year in which the officer's initial service obligation ends. This may be as early as the fourth year of service for some officers. All officers in the sample are not observed through the same number of decision points, of course. Some leave before reaching the maximum YOS, and, in some instances, the period for which there is data ends prior to reaching this point.

Estimation of panel probit models with multiple decision points has been computationally impractical because of the necessity of evaluating multiple integrals. The formulation presented above reduces the problem to the evaluation of a single

integral. However, it includes the product of several univariate normal probabilities. Butler and Moffitt (1982) have applied a numerical integration procedure based on Gaussian quadrature which reduces the computational burden.

Consider, again, the following equation:

$$Q_T=\int_{-\infty}^{\infty}\prod_{t=1}^{T}F\left[\frac{X_{j,t}\boldsymbol{\delta}-u_{\alpha}}{\sigma_{\gamma}(1-\rho)^{1/2}}-rg_j\right](2y_{j,t}-1)\frac{1}{(2\pi)^{1/2}}\exp^{-g_j^2/2}dg_j. \qquad (24)$$

Define $q^2 = g_j^2/2$, implying that $g_j = q(2)^{1/2}$. Then the expression for Q_T can be written as:

$$Q_T=\int_{-\infty}^{\infty}K_{jT}(q)\,e^{-q^2}dq\ , \qquad (25)$$

where

$$K_{jT}=\prod_{t=1}^{T}F\left[\frac{X_{j,t}\boldsymbol{\delta}-u_{\alpha}}{\sigma_{\gamma}(1-\rho)^{1/2}}-rg_j\right](2y_{j,t}-1)\frac{1}{\pi^{1/2}}. \qquad (26)$$

This integral can be approximated by

$$Q_T = \sum_{h=1}^{H}k_hK_{jT}(q_h)\ . \qquad (27)$$

where H is the number of evaluation points, and k_h are the Hermite weights for approximating the integral at the evaluation points.[12] The expression in Equation 27 is the contribution to the likelihood function for one individual observed across T decision points. Assume that the model is estimated for a sample of N officers. The log-likelihood function is expressed as:

$$\ln(L) = \sum_{n=1}^{N}\ln(Q_T)\ . \qquad (28)$$

Dependent Variables. The observed dependent variables were set equal to 1 if an individual remained on active duty for that decision year, and equal to zero if the individual separated at any time during the year. Censored and unobserved decisions were assigned a value of 0.5 in the equation.

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[12]Hermite integration is a form of numerical integration (or quadrature) that uses weighting coefficients and unequally spaced evaluation points. Allowing the evaluation points, or abscissas, to vary increases degrees of freedom, allowing one to approximate the integral fairly accurately with fewer evaluation points than in a traditional quadrature technique. For a further discussion, see Butler and Moffitt (1982).

Pay Variables. This section describes the computation of the ACOL variable, beginning with definitions of military compensation and civilian earnings.

Military compensation includes Basic Pay, Basic Allowance for Subsistence (BAS), Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA). The sum of these elements is defined as Regular Military Compensation (RMC). RMC depends on an officer's YOS, paygrade and dependent status. The definition of YOS adopted here assumes uninterrupted service—an officer's years of service for horizon year *i* are his/her current *YOS + i*. Expected pay grade is imputed by constructing weighted YOS vectors for each pay element. For example, the RMC vector for FY83 is the product of the FY83 RMC table and a table of the percentage of officers in each grade by YOS. This percentage is constructed from OPMD-branch inventories for each fiscal year. The housing allowance component of RMC is estimated as a weighted average of housing allowances for officers with and without dependents.[13] No distinction is made between members who received cash allowances and those who received in-kind benefits (*i.e.*, government-supplied housing). Officers in government quarters are assumed to receive benefits equivalent to the foregone allowances.

Military compensation also includes the present value of retirement annuities. The value for any YOS in the member's horizon equals the increase in retirement pay from staying until that horizon year. The value is zero for YOSs less than or equal to 19; the values for YOSs 20 through 30 increase with rising vesting percentages and expected basic pay.

Changes also occurred in the retirement system during the period of analysis. Those officers who entered active duty before September 1980 fall under the original retirement plan. Under this system, the officer vested at the completion of 20 years of creditable service (the end of YOS 20). The retirement annuity associated with a given horizon YOS (20 or higher) is

$$\text{Annuity} = BPAY_i * i * 0.025 \ . \qquad (29)$$

Thus, an officer retiring after 20 years receives 50% of basic pay, while he/she would get 75% after 30 years. The annuity increases annually to keep pace with the Consumer Price Index.

Officers accessing after August 1980, but before August

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[13]Officers who already had dependents at the decision point were expected to continue to have dependents. Officers without dependents, however, were assumed to have some positive expectation of acquiring dependents in future years. The model assumes that the probability of an officer remaining without dependents in YOS *i* equals the proportion of officers in YOS *i* without dependents to officers in *i - 1* without dependents.

1986, fall under a second retirement system. While their annuity is similar in terms of percentage of pay and vesting point, it is based on an average of their highest three years' basic pay:

$$\text{Annuity} = (\text{High Three})_i * i * 0.025. \tag{30}$$

The final system pertains to officers entering active duty after July 1986.[14] While the vesting years are also 20 through 30, the percentages vary from 40% to 75%. For this case,

$$\text{Annuity} = (\text{High Three})_i * (i * 0.035 - 0.3). \tag{31}$$

Retirement benefits are also adjusted for inflation. The Cost of Living Adjustment (COLA) under the newest system is one percentage point less than the CPI from retirement until age 62. At 62, the annuity makes a one-time catch-up to recover the inflation losses. After catching up, it reverts to the "CPI - 1" adjustment, but converts the pay percentage to the original calculation ($[HighThree]_i * i * 0.025$).

Retirement pay is expressed in terms of present value. Officers are assumed to receive the annuity from retirement until death at age 72. Since the annuity should (theoretically) stay constant in real dollars, the present value of the stream of payments (at the time of retirement) equals

$$\text{PV(Retirement)} = \text{Annuity} * \frac{1}{r}\left[1 - \frac{1}{(1+r)^t}\right]. \tag{32}$$

Here, r is the personal discount rate and t is the number of years for which the annuity is received.

A final element of military pay is the Voluntary Separation Incentive/Selective Separation Bonus (VSI/SSB) program. During FY92, the Army offered some officers and enlisted personnel lump-sum or annuity separation payments if they voluntarily left. The Officer Longitudinal Research Data Base (OLRDB) identifies those officers who were eligible for a VSI/SSB payment in FY92.

The present value of military pay is defined for each horizon year (i) as the discounted sum of the estimates of RMC

[14]Very few observations in the data set fall into this group, since the data include observations only through FY90.

and retirement annuities from the decision year to year *i*.[15]

$$M_i = \sum_{n=1}^{i} \left[\frac{RMC_{nk}}{(1+r)^n} + PV(Ret)_i \right]. \tag{33}$$

In this application, pay is expressed in constant FY83 dollars and the discount rate is 10%. Price-level adjustments are based on the annual percentage increase from October to October in the Consumer Price Index for all urban consumers.

Cross-Branch Effects

Previous research suggests that both the level of retention rates and the response of retention to economic incentives vary by occupational group or branch within the officer corps.[16] If this is the case, a single all-Army retention model that constrains all coefficients to be the same across branches will be misspecified, result in imprecise estimates and, perhaps, produce misleading policy implications regarding the effects of various incentives.

This research examined the retention behavior of OPMD Army officers. It included officers in the following Basic Branches:

- Infantry (IN)
- Armor (AR)
- Field Artillery (FA)
- Air Defense Artillery (ADA)
- Aviation (AV)
- Special Forces (SF)
- Corps of Engineers (EN)
- Signal Corps (SC)
- Military Police (MP)
- Military Intelligence (MI)
- Adjutant General's Corps (AG)
- Finance Corps (FI)
- Chemical (CM)
- Transportation Corps (TC)

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[15]Special pays are not included in the definition of military compensation in this research. Special pays are an addition to RMC designed to compensate officers for the negative aspects of specific duty assignments (*e.g.*, danger, time away from families). One might reasonably argue that the value of expected special pays should be included in the calculation of the ACOL variable. It is not possible, however, to accurately determine–given the available data–whether officers are to receive special pays. Moreover, it is inappropriate to include such a pay if the corresponding non-pecuniary job aspect is not included in the retention equation as well.

[16]See, for example, Mackin, *et al.* (1993) and Hogan and Goon (1990).

- Ordnance Corps (OD)
- Quartermaster Corps (QM)

While it is difficult to predict, *a priori*, the types of distortions that may occur, intuition suggests some opportunity for bias. If the all-officer model estimates are based on pooling across all branches and over time and branches with naturally higher retention rates—due to non-pecuniary factors—also have higher-than-average estimated costs of leaving, the pay (ACOL) coefficient may be biased upward because it is estimated from the cross-sectional variation in retention rates across branches. If, on the other hand, branches with high estimated costs of leaving have relatively lower retention rates (due to non-pecuniary factors) the pay coefficient may be biased downward.

The test for heterogeneity across branches involves conducting tests of linear restrictions on the coefficients. First, the model is estimated without branch-specific effects—i.e., with a single intercept and ACOL coefficient, constraining the effects of ACOL and all other variables to be the same across branches. The test model allows the intercept and ACOL coefficient to vary by branch. The hypothesis that the linear restrictions on the coefficients are appropriate is tested using a likelihood ratio test.

The estimated retention model must be used in OPICC to predict changes in retention as a function of changes in relative pay, unemployment rates, and other factors. The retention model with branch-specific effects has the following form:

$$R_t = f(\alpha + \alpha_{b1} D_{b1} + \alpha_{b2} D_{b2} + \ldots + \beta ACOL + \beta_{b1} D_{b1} ACOL_{b1} + \beta_{b2} D_{b2} ACOL_{b2} + \ldots). \tag{34}$$

where the Ds are branch-specific dummy variables that are equal to one when considering that particular branch, and are zero otherwise. To use the model in an all-Army application as a module in OPICC, the dummy variables are set equal to the proportion of the all-Army inventory that the branch, or group of branches, comprises in that particular period. For example, if D_{b1} represents Infantry, and this is about 25% of the relevant officer force, then it would be set equal to 0.25 when analyzing all-Army effects.

Decision Points Beyond Year of Service 11

In previous research, retention decisions for Army officers have been modeled only from the end of the initial term of obligated service through year of service 11.[17] In general, this

[17]Mackin, Hogan, and Mairs (1993); Mairs, Mackin, Hogan, and Tinney, (1992).

is the period during which most officers decide whether to make the Army a career, and stay at least through the twentieth year of service, or leave to pursue a civilian career. From about year of service 12 through the vesting point for military retirement at year of service 20, there are typically very few losses. Most of those who do leave are of two types, described below.

Captains who are not selected to the rank of Major may be required to leave because of the Army's "up or out" policy, codified in the Defense Officer Personnel Management Act (DOPMA). Selection to Major typically occurs at about year of service 12. Those who are passed over twice for Major will typically be separated from service, usually around year of service 12 or 13.[18] Some Captains who have failed selection to Major may be selectively retained through year of service 20, depending upon the Army's needs.

Of officers who are selected to Major, most will stay at least through the completion of 20 years of service. Of those who leave voluntarily prior to completing 20 years of service, most will do so for idiosyncratic reasons—reasons related to the officer's special circumstances—and not to marginal changes in earnings opportunities. Hence, most of the relatively few voluntary losses that occur between year of service 11 and 20 will be difficult to explain by a model of occupational choice. Table 1 illustrates the overall high rate of voluntary retention of officers between YOS 12 and YOS 20, using data on OPMD officers from the Officer Longitudinal Research Data Base.

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[18]An officer is "passed over" initially when the selection board meets to consider primarily that officer's year group for promotion, and the officer is not selected. A second "pass over" occurs when the next selection board for that rank meets and fails, again, to select the officer for promotion.

Table 1
Retention Rates for Infantry Officers by YOS and FY

	YOS								
Year Group	11	12	13	14	15	16	17	18	19
70	0.964	0.925	0.976	0.969	0.979	0.959	0.964	0.966	0.915
71	0.974	0.951	0.953	0.989	0.968	0.989	0.991	0.979	0.956
72	0.981	0.897	0.978	0.992	0.986	0.992	0.993	0.987	0.966
73	0.968	0.887	0.980	0.986	0.979	0.986	0.988	0.970	0.937
74	0.970	0.883	0.972	0.985	0.986	0.987	0.988	0.965	-----
75	0.957	0.837	0.985	0.987	0.981	0.985	0.956	-----	-----
76	0.804	0.974	0.984	0.987	0.988	0.969	-----	-----	-----
77	0.767	0.971	0.980	0.986	0.955	-----	-----	-----	-----
78	0.754	0.970	0.959	0.896	-----	-----	-----	-----	-----
79	0.755	0.949	0.933	-----	-----	-----	-----	-----	-----
80	0.971	0.821	-----	-----	-----	-----	-----	-----	-----
81	0.882	-----	-----	-----	-----	-----	-----	-----	-----
82	-----	-----	-----	-----	-----	-----	-----	-----	-----
Avg.	0.886	0.913	0.970	0.974	0.977	0.980	0.979	0.973	0.942

Of perhaps more interest is the retention behavior of officers once they reach the vesting point for military retirement (twenty years of service). Voluntary loss rates between year of service 20 and 26 are greater, and they vary over time. Hence, there is more to be explained by an economic model of occupational choice. Moreover, the ability to predict loss rates, and, perhaps, to affect those rates through policy are important. Losses in the 20-26 year of service range help determine promotion opportunities to Lieutenant Colonel and Colonel and the average quality level of the officers moving into the top Army leadership positions. Moreover, these losses—along with losses that occur from the end of obligated service to about YOS 9—will largely determine new officer requirements.

Retention beyond year of service 20, however, cannot be included in the panel probit model of occupational choice, because it would require a panel of retention decisions beginning from the end of officers' initial service obligations, typically at year of service 3, 4, or 5. This means that, including retention decisions at year of service 20 in FY90, for example, requires data on officers back to about FY76. Data in the Officer Longitudinal Research Data Base (OLRDB) begin in FY79, however. Moreover, the number of observations at higher years of service provided by a given year group are small, simply due to the continuous attrition that occurs at earlier years of service.

This research extends the panel to consider up to thirteen decisions through YOS 15 (depending on initial obligation). An important consideration in extending beyond year of service 10 is identifying those who leave involuntarily because they were not selected for Major. This is important because the ACOL-2 model attempts to explain voluntary retention decisions. If involuntary separation or (retention) is included in the estimation and treated as voluntary, the behavioral coefficients will be biased toward zero.

The OLRDB contains a field indicating whether an officer was involuntarily separated because the officer failed to be selected for Major. This variable, called the Separation Program Designator (SPD) code, can be used to identify those officers who involuntarily separate and then to censor their records in the estimation data set at the year of separation. The SPD codes which caused censored losses are listed in Table 2.[19] In addition to separations for which the SPD codes indicate an involuntary separation, some records in the estimation data set contained invalid SPD codes. Those losses were also censored.

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[19]Source: Army Regulation 635-5-1. There may be other "involuntary" SPD codes, but this list includes all identified as such from those appearing in the estimation sample.

Table 2
Involuntary Separation SPD Codes

SPD Code	Narrative Reason
BHK	Resignation; Substandard Performance
BNC	Resignation; Unacceptable Conduct
DFS	Resignation; In Lieu of Trial by Court-Martial
FHG	Resignation; Dismissal, No Review
JDK	Involuntary Discharge; Military Personnel Security Program
JFF	Involuntary Discharge; Secretarial Authority
JFL	Involuntary Discharge; Disability, Severance Pay
JFR	Involuntary Discharge; Disability, Other
JGB	Involuntary Discharge; Non-Selection, Permanent Promotion
JHF	Involuntary Discharge; Failure to Complete Course of Instruction
JHK	Involuntary Discharge; Substandard Performance
JNC	Involuntary Discharge; Unacceptable Conduct
JRB	Involuntary Discharge; Homosexual Admission
KHK	Voluntary Discharge; Substandard Performance
KNC	Voluntary Discharge; Unacceptable Conduct
JFV	Involuntary Discharge; Physical Condition, Not a Disability
KFN	Voluntary Discharge; Disability, Existed Prior to Service-Medical Board
LFV	Involuntary Release From Active Duty (REFRAD) or Transfer; Physical Condition, Not a Disability
LBK	Involuntary Release From Active Duty (REFRAD) or Transfer; Completion of Required Active Service
LCC	Involuntary Release From Active Duty (REFRAD) or Transfer; Reduction in Force
LFF	Involuntary Release From Active Duty (REFRAD) or Transfer; Secretarial Authority
LGB	Involuntary Release From Active Duty (REFRAD) or Transfer; Non-Selection, Permanent Promotion
LGC	Involuntary Release From Active Duty (REFRAD) or Transfer; Non-Selection, Temporary Promotion
LGH	Involuntary Release From Active Duty (REFRAD) or Transfer; Non-Retention on Active Duty
LHH	Involuntary Release From Active Duty (REFRAD) or Transfer; Dismissal, Awaiting Appelate Review
SCC	Retirement; Reduction in Force

Preliminary examination of a sample of OPMD officers, however, revealed that SPD may not identify all involuntary losses. Specifically, a large percentage of OPMD Captains who reach the eleventh or twelfth year of service "voluntarily" separate. Retention decisions for officers who reached YOS 12 without promoting to Major (O4) were censored from the analysis.

Civilian Earnings Estimates

An important part of an officer's decision to leave (or remain in) the Army is the officer's expectation of what he or she could earn as a civilian. In modeling the retention decision, it is typically assumed that officers form their expectations of potential civilian earnings rationally. This means that the researcher can estimate the potential civilian earnings of officers by using models that relate observations on actual earnings to the factors that theory suggests are determinants of those earnings—e.g., education and experience—and predict the potential earnings of officers from these models.

Using data on actual earnings of civilians, one can estimate earnings equations and use the model to predict civilian earnings for military officers by entering the officers' characteristics into the equation. In Mackin, Hogan, and Mairs (1993), civilian earnings data from the 1979 Current Population Survey (CPS) were used to estimate the potential earnings of Army officers. The CPS data consist of the earnings of civilians (some of whom were veterans) and their characteristics—education, imputed experience, and demographic characteristics. Potential civilian earnings of military officers are estimated from the model under the assumption that the expected earnings of Army officers and civilians in the civilian sector differ only as a function of differences in the characteristics that are measured in the model.

There are two, related, shortcomings associated with using civilian data, such as the CPS, to infer the potential earnings of Army officers. First, military officers may differ, systematically, from their civilian counterparts in unmeasured ways that are systematically related to potential earnings. They chose to enter the Army when civilians chose to pursue alternative careers. The Army, in turn, accepted them as officers only after they had passed screens related to physical, moral, and mental fitness for service. For these reasons, it may be misleading to infer potential civilian earnings of officers from equations estimated from actual civilian earnings of individuals who were not military officers.

The second shortcoming is that there is no basis for estimating the effect of military experience on civilian earnings. Predictions based on models estimated from earnings of civilians who have no measured military experience typically

assume that a year of military experience has the same effect on civilian earnings as a year of civilian experience. If, on the other hand, military experience is not a perfect, one-for-one substitute for civilian experience, earnings estimates may be biased.

Moreover, if officers understand that the opportunity cost of an additional year of military service is not solely the foregone civilian earnings for that year, but a shift in the entire civilian earnings profile, rationality implies that they will take this into account in their retention decision. This more complicated process requires a revision to the calculation of the Annualized Cost of Leaving, to account for the effect of military experience on the entire profile of potential civilian earnings.

Recall that in the original computation of ACOL at year of service 1^* at time t^*, $ACOL_{1^*,t^*}$, the individual is assumed to compare the earnings stream from staying h more years to an earnings stream if the decision were to leave immediately. The former consists of serving until year of service $(1^* + h)$, at calendar time $(t^* + h)$, and then entering the civilian sector at that time and earning C_{t^*+h}. If the officer were to retire from the labor force at time T, then the present value of the return to staying h more years is:

$$RS_{1^*,t^*}(h) = \sum_{i=1}^{h} \frac{[M_{1^*+i,t^*+i}]}{(1+r)^i} + \sum_{i=h+1}^{T} \frac{[C_{t^*+i} + A_{t^*+i}(1^*+h)]}{(1+r)^i} . \qquad (35)$$

where $A_t(1^* + h)$ represents the military retirement annuity from serving $(1^* + h)$ years.

The present value of the return to leaving at t^* is given by:

$$RL_{t^*}(1^*) = \sum_{i=1}^{h} \frac{C_{t^*+i} + A_{t^*+i}(1^*)}{(1+r)^i} + \sum_{i=h+1}^{T} \frac{C_{t^*+i} + A_{t^*+i}(1^*)}{(1+r)^i} . \qquad (36)$$

The net returns to staying h more periods, then, are $RS - RL$. Because the individual's potential civilian earnings are independent of the mix (military vs. civilian) of experience, civilian earnings beyond period $(t^* + h)$ subtract out.

Now, revise the computation for the net present value of the returns to staying through period $(t^* + h)$ to reflect the notion that the effect of military experience on civilian earnings may be different than the effect of civilian experience on civilian earnings. Let $C_{t^*+k}(t^*)$ represent the expected civilian earnings of an officer in period $(t^* + k)$, who leaves military service and enters the civilian sector at period t^*. In general, in this formulation, $C_{t^*+k}(t^*) \neq C_{t^*+k}(t^*+1)$. Revising the expressions for the return to staying and the return to leaving, we obtain:

$$RS_{l^*,t^*}(h) = \sum_{i=1}^{h} \frac{M_{l^*+i,t^*+i}}{(1+r)^i} + \sum_{i=h+1}^{T} \frac{C_{t^*}(t^*+h)_{+i} + A_{t^*+i}(l^*+h)}{(1+r)^i}. \qquad (37)$$

and

$$RL_{t^*}(l^*) = \sum_{i=1}^{h} \frac{C_{t^*+i}(t^*) + A_{t^*+i}(l^*)}{(1+r)^i} + \sum_{i=h+1}^{T} \frac{C_{t^*+i}(t^*) + A_{t^*+i}(l^*)}{(1+r)^i}. \qquad (38)$$

In general, civilian earnings beyond the horizon (*h*) no longer subtract out in the expression for the net present value of the returns to staying *h* more periods (*RS - RL*). If civilian experience increases civilian earnings more than military experience, the cost of staying an additional year includes a component representing the present value of the difference in future civilian earnings due to the difference in civilian experience implied by a stay of an additional year.[20]

Hence, in principle, it would be useful to estimate civilian earnings equations using data consisting of the actual earnings of civilians who are veterans of the Army officer force, and to allow separate effects on earnings from military and civilian experience in these models. Earnings equations would be of the form:

$$\ln C_t = \alpha + \beta_1 \mathrm{MilExp} + \beta_2 \mathrm{MilExp}^2 + \beta_3 \mathrm{CivExp} + \beta_4 \mathrm{CivExp}^2 + \ldots \qquad (39)$$

where C_t is an observation on the civilian earnings of a former military officer at time t. However, earnings data is not systematically collected for military veterans.

The only existing data set with veterans earnings from which to estimate such a model is the Defense Manpower Data Center's

[20]Matthew Goldberg and John Warner, using data from the Post-Service Earnings History File (PSEHF), find that a year of military experience contributes less than a year of civilian experience to civilian earnings growth. See Goldberg and Warner (1987).

Post-Service Earning History File (PSEHF). The earnings data was obtained from the Internal Revenue Service (IRS) and the Social Security Administration, and is grouped by them to preserve confidentiality. It consists of observations on the earnings of veterans who *separated* from military service over the period 1972 through 1980. Approximately 255,000 officers from the four services who separated over the period were placed into cells defined by Service, year of service, education, rank, year of separation and military occupation. No cell contains more than 25 members. Cell averages of other potentially relevant characteristics, such as number of dependents, are appended. The IRS attached the W-2 earnings of each member in the cell for 1979 through 1983, while SSA did the same for social security earnings for 1972 through 1980. Both sets of earnings are potentially truncated. For SSA, the truncation is at the social security ceilings, while for IRS the truncation is at an annual earnings level of $150,000.

Hogan and Goon (1990) used the PSEHF to estimate civilian earnings equations for Air Force officers. These were used in an ACOL model of officer retention, using an algorithm in which civilians earnings opportunities were a function of the mix of civilian and military experience. The same model was also estimated using earnings equations from the Current Population Survey. The retention model using the CPS earnings data appeared to provide results that were more consistent with the literature on officer retention.

The major advantage of estimating civilian earnings using the PSEHF is that expected civilians earnings estimates could become a function of the mix of military and civilian experience. This consideration, that one's military experience is less valuable in the civilian sector than civilian experience, should affect officers' retention decisions.

The major disadvantage of this approach is the nature of the data with which to estimate the earnings equations. The data are relatively old. They overlap only slightly with the period over which the retention equations will be estimated. Moreover, the data are grouped. Because of this, earnings equations will be estimated with less precision than they otherwise might. For these reasons, we propose not to estimate the civilian earnings equations using the PSEHF. Estimation of an earnings equation that accounts for the mix of military and civilian experience should await the development of a new data set on post-service earnings.

The civilian earnings equation used for this analysis used a pooled cross-section/time series sample from the Current Population Survey. The sample included observations from the March Annual Demographic File for 1988 through 1992. The CPS file is compiled by the Bureau of the Census for the Bureau of

Labor Statistics. It provides data (includes information on civilian earnings and demographics such as salary, work experience, education, gender and age) on a representative cross-section of the population.

The initial random sample from the five files included 25,765 person records. Individuals who were not full-time members of the labor force and between the ages of 17 and 65 were excluded, resulting in a final sample of 8,677 person records. Table 3 shows the sample size broken out by year. Annual earnings reported were weighted to adjust for inflation; the adjusted earnings numbers were expressed in constant October 1982 dollars. Table 3 also shows the weighting variables applied to each year's observations.

Table 3
CPS Sample Size and Inflation Factors

Year	Sample Size	Inflation Factor
1988	1,763	0.8429
1989	1,646	0.8029
1990	1,815	0.7630
1991	1,716	0.7274
1992	1,737	0.7050

These 8,677 observations represented a subset of the sample extracted from the CPS data files which were conditional on the individual being a member of the labor force between the ages of 17 and 65 and being employed in a full-time capacity. The original sample set, which contained 25,765 observations, was extracted from the CPS Annual Demographic files by random selection.

Two models were estimated. The first regressed the natural logarithm of wages on experience, experience squared, gender, race (white or nonwhite), an educational variable measuring the effects of additional levels of education completed as well as two variables representing field of occupation. The second model regressed the natural logarithm of wages on experience, experience squared, gender, race, an educational variable (as described above), two occupational variables and dummy variables for each year included in the data set. Table 4 and Table 5 report the results of each of these estimations.

Table 4
Civilian Earnings Equation (1)

Variable	Estimate	Mean	Standard Dev.	t-stat.
Intercept	8.47	9.61	0.81	7176.8
Experience	0.06	19.66	11.67	995.4
Experience^2	-0.0009	522.84	555.59	-767.6
Female	-0.35	0.42	0.49	-910.3
Nonwhite	-0.21	0.14	0.34	-375.0
High School	0.48	0.46	0.50	452.3
Some College	0.73	0.23	0.42	657.7
Bachelors	0.98	0.16	0.36	854.8
Bachelors Plus	1.12	0.11	0.32	949.13
Engineer	0.29	0.02	0.15	224.0
Social Science	0.27	0.00	30.05	71.3

Table 5
Civilian Earnings Equation (2)

Variable	Estimate	Mean	Standard Dev.	t-stat.
Intercept	8.44	9.61	0.81	6752.0
Experience	0.06	19.66	11.67	998.4
Experience^2	-0.0009	522.84	555.59	-770.3
Female	-0.35	0.42	0.49	-910.6
Nonwhite	-0.21	0.14	0.34	-375.4
High School	0.48	0.46	0.50	452.0
Some College	0.73	0.23	0.42	657.9
Bachelors	0.98	0.16	0.36	856.3
Bachelors Plus	1.12	0.11	0.32	947.8
Engineer	0.29	0.02	0.15	224.4
Social Science	0.27	0.00	30.05	71.6
Year 88	0.05	0.20	0.40	80.6
Year 89	0.03	0.20	0.40	58.8
Year 90	0.04	0.21	0.41	70.7
Year 91	0.02	0.20	0.40	30.9

The ACOL calculation used the results of Equation 1.

Link Between Retention and Promotion/Performance

Previous models of Army officer retention have used relatively static measures of promotion opportunities. Computation of expected future military earnings for individual officers is predicated on an average rate of promotion, which is assumed not to vary over time, in these models. If promotion opportunities vary both over time and across individuals in a given period, it is reasonable that this variation would affect the voluntary retention decisions of individual officers.

Directly incorporating the effect of changes in promotion policies in the retention model would, in principle, allow both for improved prediction of retention rates and, possibly, additional policy insights regarding the effect of promotion policies on retention. Of particular interest is whether top-performing officers' retention decisions are more sensititve to changes in promotion policies (e.g., changes in promotion speed and probability). If so, policies which increase the dispersion in promotion times may encourage the retention of top-performing officers, while discouraging retention of underachieving officers—policies that are important during a period of reduced force size.[21]

Incorporation of officer-specific individual promotion times in the ACOL estimate of the financial cost of leaving is not a trivial matter, however. If a model of individual promotions is estimated and used to predict individual officer promotion times, and this model contains more information regarding the underlying "quality" of the officer than is available in the prediction of expected civilian earnings, the resulting estimate of the ACOL parameter is likely to be biased low. The reason for this likely bias is that underlying officer "quality" is likely to affect both Army promotion times and, through this, military earnings and civilian earnings opportunities. Including only the effect on military earnings, through its effect on promotion times, will systematically overstate the cost of leaving for officers expected to have faster promotions, and understate the ACOL values for officers expected to have slower promotions. Hence, the coefficient on ACOL in such a model is likely to be biased low. If the promotion information affects only military earnings

[21]Moreover, it suggests, perhaps, a more important role for promotion policies. If the rewards for high performance are increased relative to average or low performance, the incentive to exert effort to achieve higher levels of performance may be increased. Promotion policies which increase the "payoff" to high performance could increase the average level of officer performance by encouraging all, or most, officers to exert greater effort. See, for example, John T. Warner and Beth Asch, "Should the Military Retirement System Be Maintained in Its Present Form?", a paper presented at the conference, "A Military of Volunteers: Yesterday, Today, and Tomorrow," U. S. Naval Academy, September 15-17, 1993.

and not expected civilian earnings, no bias is introduced from this source. This would argue for incorporating information that predicts promotion that is either (a) also included in the civilian earnings estimates, such as education, or (b) unrelated to civilian earnings, such as changes in average promotion rates for cohorts based on internal Army supply and demand conditions.

If individual-specific information on expected promotion is incorporated in the ACOL calculation through promotion times, one can attempt to reduce or eliminate the likely bias by also including the individual-specific expected promotion time as an explanatory variable in the retention equation.[22] However, the ACOL variable loses its structural interpretation because the promotion-time variable captures a part of the effect on civilian earnings opportunities associated with officers with above- or below-average promotion times attributable to their inherent "quality" differences.[23]

Buddin, et. al. (1992) and Shiells and McMahon (1993) analyze the relationship between advancement or promotion and retention as a simultaneous system.[24] The former consider first-term enlisted members in the Army and the Air Force, while the latter considers the retention and advancement of first-term enlisted personnel in the Navy. Both structure the problem as a simultaneous system with promotion times and retention as jointly determined variables. Shiells and McMahon (1993) were unable to separately identify the promotion and retention equation. Buddin, et. al. (1992) found that, when individual-specific promotion times are included in measure of the financial opportunity cost of reenlistment (an ACOL variable) along with a separately entered measure of individual-specific expected promotion time, the pay elasticity declined significantly. However, because expected promotion times were assumed to be related only to military earnings and not to affect civilian earnings through their implicit relation to "quality," it is not clear that a structural pay elasticity has been identified.

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[22]This is done, for example, in Buddin, et. al. (1992).

[23]Buddin, et. al. (1992) interpret the coefficient on the promotion time variable as the effect of the non-pecuniary advantages of faster, or slower, promotion times. If differences in inherent "quality" generate differences in promotion times, the measure will also include the effects of omitted factors from the civilian earnings equation.

[24]Martha Shiells and Joyce S. McMahon, "Effects of Sea Duty and Advancement on First-Term Retention," *Center for Naval Analyses*, CRM 92-205, June 1993.

In the case of the Army officer retention model considered here, jointly modeling promotion and retention is problematic for three reasons:

1. **Lack of variation in promotion times through Captain**—Promotion times of Army officers through the rank of Captain do not vary a great deal. Most officers are promoted to this rank, and most are promoted "on-time" or in due course. Moreover, for those who are promoted early to the rank of Captain, there are few observable factors that would make this event predictable.

2. **Up-or-out policy for promotion to Major**—There is somewhat more variation in the promotion to Major, but the degree of variation is still small. Most officers are promoted to Major on time. Those who are not promoted will be asked to leave the Army. If the officer is forced to leave through "up-or-out" policies, he or she receives separation pay. Hence, for most officers who remain in service through YOS 9 or 10, there is an incentive to remain through YOS 12 or 13, then leave if passed over for Major. Again, there are relatively few factors that are observable to the researcher that would permit prediction of promotion times to Major.

3. **Promotions to Lieutenant Colonel and Colonel that are beyond the range of retention decisions for analysis**—Real differentiation occurs in promotion to Lieutenant Colonel and to Colonel. Selection ratios are smaller, and there is greater variation in promotion time for those selected. In addition, there are observable events in the career path that are likely to affect promotion probability and timing, and that could be used in a promotion model, such as successful completion of professional military education, tour as a battalion commander, and service in key staff positions in the Pentagon or a MACOM. Unfortunately, however, promotion to the ranks of O-5 and O-6 typically occurs between years of service 15 and 23, which are beyond the years of service included in this analysis. The financial implications of retiring as an O-5 rather than an O-4 are great. Even as early as YOS 12, those who have a higher probability of making O-5, other things being equal, will be more likely to stay through 20 years of service. It is unlikely that one could construct models that would distinguish (conditional on information available at year of service 10 or 12) which officers were more likely to achieve the rank of O-5 or O-6, and estimate the time required to achieve the rank.

In addition, incorporating individual-specific promotion information in the calculation of the ACOL variable may be undesirable if it is impossible to incorporate the effect that this information implies about civilian earnings opportunities.

DATA

The econometric estimation used data on individual OPMD officer retention decisions made from FY 1979 through FY 1992. This period included several years of sustained growth in the officer force as well as more recent years of downsizing. It also includes a wide variation in the levels of real and nominal pay.

The main source of data was the Officer Longitudinal Research Data Base (Ramsey and Fertig, 1995). The OLRDB provided grouped statistics on the OPMD branches, counts of officers in the relevant basic year groups, and individual records for the estimation data set.

Summary statistics for year groups 1979 through 1989 (the cohorts observable in the period of analysis) were compiled. The OLRDB contained about 80,500 eligible records. Based on this information, a "one-in-seven" random sample of OPMD officer records was drawn, yielding about 12,000 observations. A similar-sized sample was also drawn for out-of-sample testing.

Once the sample was extracted, Procurement Program Numbers (PPNs) from the Officer Master File were appended to each record. The PPN (not available on the existing OLRDB) provides the most accurate measure of initial obligation.

Other data were necessary to construct the estimation data set, including the civilian earnings equation (discussed above); estimates of real wage growth in the civilian sector (from the Current Population Survey); basic pay and RMC tables for FY 1979 through FY 1992; the percentage of officers with dependents by YOS (from the OLRDB); national unemployment rate by fiscal year (from the Bureau of Labor Statistics); and the Consumer Price Index by fiscal year (also from BLS).

The estimation data set was constructed using information on each OLRDB sample observation to characterize up to thirteen retention decisions as "stay" or "leave." Records containing bad data, invalid branches, or missing key information were deleted from the data set. ACOL variables were calculated for each valid decision point.

Table 6 shows mean values for key variables by decision point for the estimation data set.

Table 6
Mean Values for Key Variables

			Mean Values				
Decision Pt.	N	Retention Rate	Non-white	Female	Cost of Leaving ($)	Unemployment Rate Index	No. of Dependents
1	8,978	0.842	0.188	0.108	13,226	1.158	1.015
2	6,919	0.894	0.194	0.100	14,185	1.167	1.219
3	5,702	0.934	0.199	0.093	15,276	1.155	1.449
4	4,871	0.951	0.205	0.088	16,409	1.133	1.659
5	4,240	0.952	0.210	0.083	17,807	1.088	1.844
6	3,636	0.965	0.206	0.079	19,542	1.043	2.018
7	3,030	0.966	0.203	0.073	21,854	1.019	2.175
8	2,471	0.970	0.205	0.071	24,319	0.998	2.313
9	1,782	0.960	0.208	0.065	27,786	0.979	2.450
10	1,238	0.993	0.187	0.050	32,493	0.960	2.553
11	987	0.981	0.181	0.042	38,137	0.967	2.652
12	603	0.968	0.194	0.036	41,752	1.009	2.665
13	288	0.965	0.198	0.035	48,174	1.038	2.802

RESEARCH FINDINGS

The econometric model described above was estimated for a sample of U.S. Army OPMD Branch officers. Individual officers were observed at annual decision points from the end of initial obligation until they reached YOS 15 or decision point 13, or until they left active duty. The model was estimated with and without branch effects included. Table 7 reports the estimation results for a basic specification of the model in which no branch effects were measured (Equation 1). Table 7 also reports the results for a simple probit estimate in which ρ is forced to zero (Equation 2).

Table 7
Primary Specification Results

	Equation 1		**Equation 2**	
Variable	**Estimate**	**t stat.**	**Estimate**	**t stat.**
Intercept	0.683373	9.674	0.329230	4.77
Nonwhite	0.276765	9.036	0.234410	9.48
Female	-0.214897	-6.018	-0.173630	-5.96
ACOL	0.000018	6.273	0.000055	22.59
Unemployment	-0.002187	-0.299	0.016700	0.39
No. of Deps.	0.108262	12.005	0.101900	13.05
ρ	0.471013	5.338	-------	-----
Log Likelihoods				
Full Model		-11,173.8		-11,307.5
Restricted Model		-12.170.9		-12,049.9
Likelihod Ratio (χ^2)		1,994.2		1,484.8

All of the coefficients in both equations, with the exception of unemployment, are significant at the 0.05 level. The log-likelihood test for both specifications rejects the null hypothesis that the coefficients are zero. The estimated correlation coefficient (ρ) is significant in Equation 1, providing strong evidence that fixed effects are present. Moreover, Equation 2 shows that failing to control for fixed effects causes an overestimate of the pay effect.

Branch Effects

Adding branch-specific terms to the retention equation produced mixed results. Table 8 reproduces the results from Equation 1. In addition, it includes estimates that include

branch dummies (Equation 3) and branch dummies plus interactions between the branch dummies and the ACOL variable (Equation 4). Estimates marked with a "*" are significant at the 0.05 level, while coefficients marked "**" are significant at the 0.10 level.

Table 8

Branch-Effect Results

Variable	Equation 1	Equation 3	Equation 4
Intercept	0.683373*	0.761727*	0.648636*
Nonwhite	0.276765*	0.301126*	0.300155*
Female	-0.214897*	-0.222578*	-0.220092*
Branch Effects (IN Omitted)			
AD	--------	-0.272965*	-0.345210*
AG	--------	-0.101273**	0.091819
AR	--------	-0.156491*	-0.220561**
AV	--------	0.169303*	0.761751*
CM	--------	-0.212252*	-0.146906
EN	--------	-0.337778*	-0.490008*
FA	--------	-0.178129*	-0.178339**
FI	--------	-0.275733*	0.019047
MI	--------	-0.040709	0.075652
MP	--------	-0.007227	0.371349*
OD	--------	-0.058037	-0.175284
QM	--------	0.014324	-0.396542
SC	--------	-0.190921*	-0.274554*
SF	--------	0.788620*	1.708558*
TC	--------	-0.109544**	0.136795
ACOL	0.000018*	0.000017*	0.000024*
AD*ACOL	--------	--------	0.000005
AG*ACOL	--------	--------	-0.000012**
AR*ACOL	--------	--------	0.000004
AV*ACOL	--------	--------	-0.000036*
CM*ACOL	--------	--------	-0.000004
EN*ACOL	--------	--------	0.000010

Table 8

Branch-Effect Results

Variable	Equation 1	Equation 3	Equation 4
FA*ACOL	--------	--------	0.000000
FI*ACOL	--------	--------	-0.000018
MI*ACOL	--------	--------	-0.000007
MP*ACOL	--------	--------	-0.000024*
OD*ACOL	--------	--------	0.000008
QM*ACOL	--------	--------	0.000027*
SC*ACOL	--------	--------	0.000005
SF*ACOL	--------	--------	-0.000049*
TC*ACOL	--------	--------	-0.000016**
Unemployment	-0.002187	0.001316	0.003625
No. of Deps.	0.108262*	0.104688*	0.103191*
ρ	0.471013*	0.477320*	0.454833*
Likelihood Ratio	1,994.2*	1,670.5*	2,516.1*

Equation 3 yielded significantly different retention effects for nine branches. Officers in the AD, AR, CM, EN, FA, FI and SC branches were less likely to stay in the Army than were Infantry Branch officers. Aviation and Special Forces Branch officers were more likely than Infantry officers to stay in the Army. By far, the SF effect was the largest—other things being equal, a white, male Special Forces officer was 12.5 percent more likely to stay at the first retention decision than was an otherwise similar Infantry officer. This result is not unexpected, since one would expect a fair amount of self-selection into the SF branch (only those officers with a strong taste for the Army would volunteer for Special Forces).

Adding interaction terms between each branch effect and the ACOL variable had mixed results. The branch effect for the MP branch became significant and positive, and the branch effects for five branches (AG, AR, CM, FI, TC) that were significant in Equation 3 were no longer significant in Equation 4. Several interaction coefficients were also significant. AG, AV, MP, SF and TC officers were less responsive to changes in relative pay than were Infantry officers, while QM officers were slightly more responsive to pay. In the three cases where both the branch and interaction effects were significant at the 0.05 level, officers were more likely to stay, but less responsive to pay changes.

Since the results of this comparison are not conclusive, the null hypothesis that branch effects are zero (retention behavior does not vary by branch) can be tested using a likelihood ratio test. The likelihood ratio test statistics reported in the tables above compare the log-likelihoods of the full model with a "restricted" model in which all coefficients except the intercept are forced to zero. In this case, Equation 1 serves as the restricted model for comparison with Equations 3 and 4.

The likelihood ratio test statistic for comparing Equation 3 with Equation 1 is 190.7 with fifteen degrees of freedom, with which one can reject the null hypothesis that branch effects do not matter at better than the 0.001 error level. A test of Equation 4 versus Equation 1 yields a similar result, with a test statistic of 261.4 with thirty degrees of freedom. Finally, the test statistic, comparing Equation 4 versus Equation 3 equals 70.7 with fifteen degrees of freedom, is also significant at better than the 0.001 level. However, the specific branch-slope effects are significant in only a small number of cases.

Obligation Effects

Another specification issue concerned the impact of mixing the retention decisions of officers at different years of service. Depending on the initial obligation, officers could make their initial retention decisions in YOS 3, 4 or 5. There are at least two reasons to suspect that observed behavior across initial obligations could differ. First, officers may sort themselves by non-pecuniary preferences when they select an accession program that incurs more or less obligation. Second, officers with longer obligations may leave at higher rates at the first decision point. To see this, imagine that each officer determines an optimal leaving point between 0 and 30 years. For officers with three-year initial obligations, the first-decision loss rate would be the proportion who would voluntarily choose to leave after three years or sooner. For those with five-year obligations, the loss rate would include all those who would choose to leave after five years or sooner. For the estimation sample, 12.2 percent of officers with three-year obligations left at the first opportunity, compared to 22.7 percent of four-year obligors and 19.8 percent of five-year obligors.

Table 9 compares Equation 1 to Equations 5, 6 and 7, which present the estimation results separately for three-, four- and five-year obligors, respectively.

Table 9

Retention Effects by Initial Obligation

Variable	Equation 1 All Obligations	Equation 5 3-Year Obligation	Equation 6 4-Year Obligation	Equation 7 5-Year Obligation
Intercept	0.683373*	0.850061*	0.405780*	-0.040388
Nonwhite	0.276765*	0.212792*	0.204723*	0.129193**
Female	-0.214897*	-0.239693*	-0.198438*	-0.240968*
ACOL	0.000018*	0.000021*	0.000025*	0.000044*
Unemployment	-0.002187	-0.003297	-0.014571	0.026436**
No. of Deps.	0.108262*	0.096435*	0.091375*	0.063467*
ρ	0.471013*	0.317301*	0.606970*	0.402101*
Likelihood Ratio (χ^2)	1,994.2*	990.0*	808.9*	1,492.5*
N	8,978	5,461	1,959	1,558

The first result of stratifying the sample by initial obligation is an increase in the pay effects—modest for three- and four-year obligation groups, but fairly substantial for officers with a five-year obligation. Nonwhite and female effects remained about the same, although the coefficient on female is smaller and only significant at the 0.10 level for the final group (Equation 7). Finally, those with three- or five-year obligations showed lower correlation between successive decisions; four-year obligors demonstrated much higher correlation.

Attributes-in-ACOL Effect

The final specification test conducted for this research was to estimate the model using ACOL values calculated with each individual's attributes, rather than mean sample values, in the civilian earnings equation. Table 10 compares the basic specification to Equation 8, which used the alternative ACOL calculation. Equation 9 uses the same alternative ACOL calculation, but also includes the individual attributes as explanatory variables in the retention equation.

There does not appear to be a dramatic difference between the two ACOL specifications. In the absence of demographic explanatory variables, the alternative ACOL specification yields a slightly smaller pay coefficient and a somewhat larger correlation coefficient (Equation 8). It is possible that the individual attributes pick up some of the fixed effect, so that omitting them results in a higher value for ρ.

Table 10

Impact of Individual Attributes in the ACOL Calculation

Variable	Equation 1	Equation 8	Equation 9
Intercept	0.683373*	0.835924*	0.669110*
Nonwhite	0.276765*	------	0.225127*
Female	-0.214897*	------	-0.304615*
ACOL	0.000018*	0.000011*	0.000015*
Unemployment	-0.002187	0.009858	0.006524
No. of Deps.	0.108262*	------	0.103811*
ρ	0.471013*	0.579924*	0.493526*
Likelihood Ratio (χ^2)	1,994.2*	764.0*	2,067.6*

The results for Equation 9 show a small impact on the estimated effect for Nonwhite and Female. Using individual attributes to calculate the ACOL value resulted in a somewhat smaller positive effect for nonwhites and a somewhat greater negative effect for females. In addition, the ACOL coefficient was slightly smaller than in the original specification. None of the coefficients, however, switched sign or lost significance.

Pay Effects

The structure of the probit model and the indirect relationship between the ACOL variable and pay levels make it difficult to interpret the pay coefficients. Perhaps the most useful way to interpret these results is by simulating a pay elasticity. This is accomplished by calculating baseline ACOL values and predicted retention probabilities for a "typical" officer (e.g., a white, male, Infantry Branch officer) at each decision point. Then, the ACOL values are recalculated with RMC and Basic Pay increased by 10%. The resulting percentage change in retention probability is divided by the percentage change in military pay to produce the pay elasticity.

Table 11 displays simulated pay elasticities for a white, male, ROTC graduate in the Infantry Branch for the seven equations displayed above.

Table 11

Simulated Pay Elasticities

Decision Point	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.198	0.426	0.170	0.236	0.174	0.386	0.599
2	0.146	0.393	0.128	0.174	0.120	0.281	0.402
3	0.116	0.352	0.103	0.141	0.087	0.228	0.295
4	0.103	0.352	0.093	0.128	0.082	0.208	0.292
5	0.092	0.351	0.083	0.109	0.085	0.186	0.301
6	0.088	0.326	0.081	0.107	0.086	0.162	0.227
7	0.060	0.297	0.056	0.075	0.059	0.136	0.183
8	0.035	0.258	0.032	0.041	0.039	0.133	0.175
9	0.037	0.212	0.031	0.035	0.044	0.124	0.153
10	0.041	0.164	0.033	0.033	0.045	0.110	0.121
11	0.043	0.120	0.035	0.034	0.043	0.093	0.088
12	0.043	0.110	0.037	0.038	0.045	0.079	-----
13	0.038	0.053	0.033	0.029	0.034	-----	-----

The pay elasticities are interpreted as follows. Using the Equation 1 results, a one-percent increase in military pay increases the probability that an officer will stay at the first decision point by about 0.2 percent. A comparison of Equations 1 and 2 implies that failing to control for unobserved heterogeneity across multiple retention decisions overstates the impact of pay. One property of the construction of the ACOL variable is that, especially in the absence of significant special pays, the value of ACOL rises with tenure. At the same time, retention rates rise as well. The simple probit model (Equation 2) ignores the effects of unobserved heterogeneity and attributes its impact to the pay variable.

Pay elasticities fall with tenure in all specifications, which is consistent with previous research. One reason for the decline is that base retention rates rise with tenure. Second, as officers become more senior, the value of retirement annuities begins to dominate the ACOL value and the importance of current military pay declines. Allowing the ACOL variable to interact with branch indicators appears to have increased the size of the pay effect slightly.

Demographic Effects

The direction of the effect of the other explanatory variables, but not its magnitude, can be easily observed. For dichotomous (dummy) variables, the appropriate way to interpret their impact is to calculate the impact of a unit increase in their value on retention probabilities. Using this technique and the results of Equation 1, non-white officers are about 6.4 percentage points *more* likely to stay than an otherwise similar white officer. By contrast, a female officer is about five percentage points *less* likely to stay. Each additional dependent increases retention probabilities by about 2.5 percentage points.

Predictive Power: Panel vs. Pooled Probit

The ultimate test of the model's accuracy must be its ability to predict retention behavior accurately. This research used the estimation results to predict retention behavior for a separate sample of OPMD officers drawn from the same analysis periods. Table 12 compares the observed retention patterns with predicted patterns for Equations 1, 2, 4 and 5-7.[25] These numbers are also presented graphically in Figure 1.

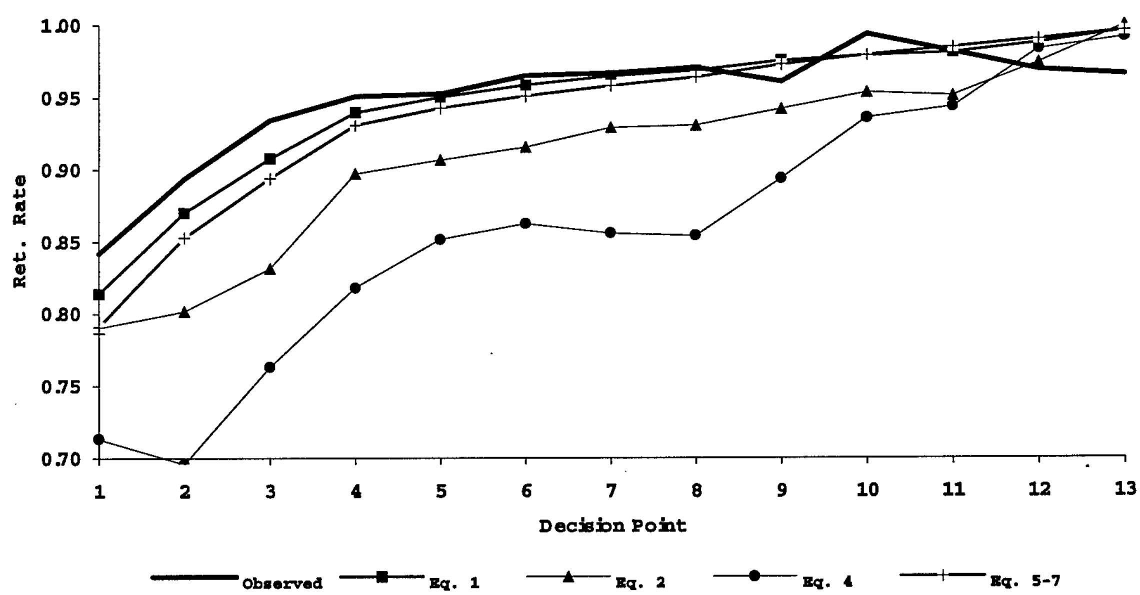

Figure 1: Observed vs. Predicted Retention

[25]The predicted results for Equations 5-7 are weighted averages from all three samples.

Table 12

Observed vs. Predicted Retention

Dec. Pt.	Observed Retention Rate	Predicted Retention Rates Eq. 1	Eq. 2	Eq. 4	Eq. 5-7
1	0.8419	0.8138	0.7903	0.7132	0.7909
2	0.8938	0.8702	0.8016	0.6957	0.8530
3	0.9342	0.9076	0.8313	0.7632	0.8939
4	0.9505	0.9395	0.8972	0.8177	0.9306
5	0.9521	0.9500	0.9066	0.8516	0.9424
6	0.9645	0.9580	0.9153	0.8623	0.9507
7	0.9660	0.9641	0.9287	0.8556	0.9575
8	0.9696	0.9677	0.9301	0.8538	0.9633
9	0.9602	0.9743	0.9416	0.8934	0.9718
10	0.9927	0.9779	0.9529	0.9355	0.9782
11	0.9808	0.9800	0.9508	0.9432	0.9837
12	0.9685	0.9868	0.9733	0.9826	0.9894
13	0.9653	0.9956	0.9992	0.9909	0.9955

The basic specification of the model clearly provides the closest fit of predicted to observed values. Equations 5-7 (stratified by initial obligation) provided about the same level of accuracy, although their predicted values were consistently lower than the Equation 1 results. The pooled probit results (Equation 2) consistently underpredict retention until the last two decision points, while Equation 4 (branch interaction effects exhibit the largest discrepancy.

Based in part on these results, the basic specification (Equation 1) was used to provide parameters for the OPICC model.

THE OFFICER PERSONNEL, INVENTORY, COST AND COMPENSATION (OPICC) MODEL PROTOTYPE

The Officer Personnel Inventory, Cost and Compensation (OPICC) model allows Army policy analysts to apply reliable econometric parameters to project inventory effects of policy actions and perceived changes in external economic conditions. This section provides discussion of the methodologies and algorithms underlying the model -- how retention rates are applied, losses calculated, promotions determined, etc. It also discusses OPICC's retention "engine" (the ACOL methodology and how OPICC applies it to modify retention rates). The OPICC User Manual offers a more comprehensive description of the model.

OPICC's Ager: Structure and Function

The underlying methodology in OPICC is a Markov-process (deterministic) ager. That is, it begins with a baseline (starting) force and applies non-stochastic transition rates to that force. Policy levers and predicted econometric effects allow some of the rates and parameters to change across the projection period. Figure 2 provides a top-level summary of the aging process for one projection year.

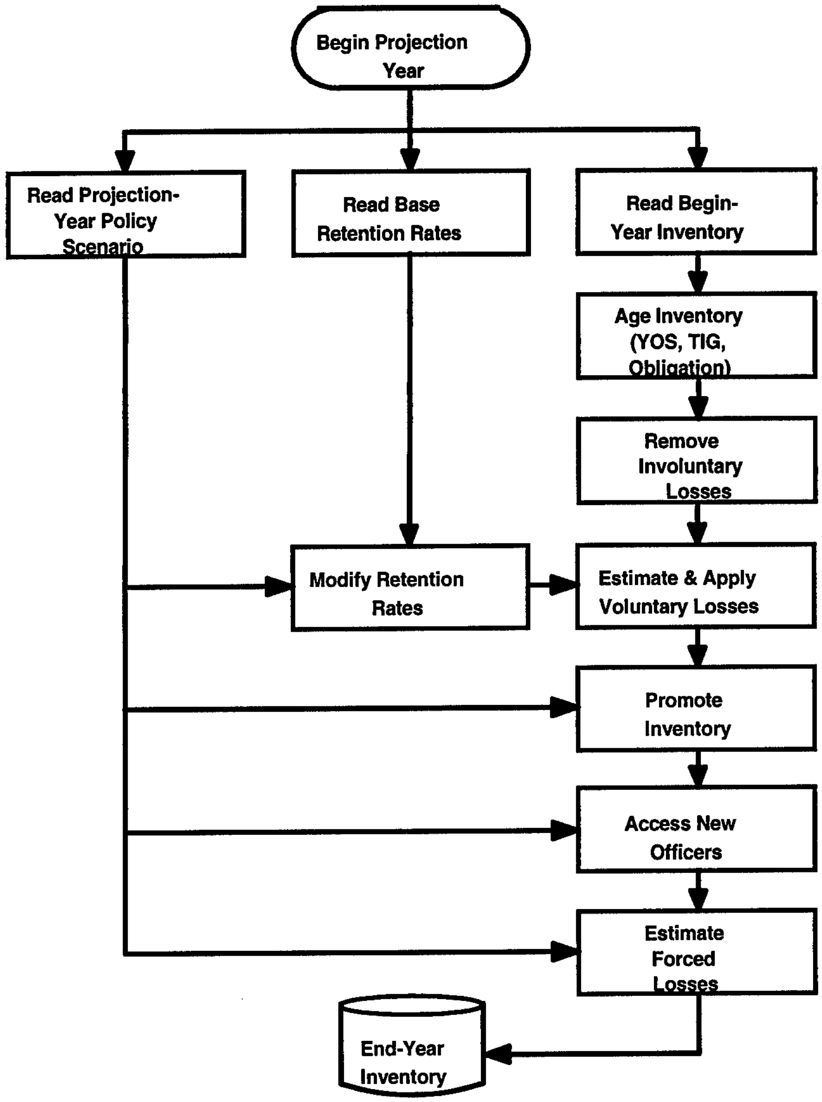

Figure 2: OPICC Model Inventory Ager

The OPICC initial inventory is constructed from a "snapshot" of the Officer Master File (OMF). Individual officers are aggregated into cells by Years of Service (YOS), Paygrade (O1-O6,O7+), Time in Grade (TIG) and Length of Obligation.[26] Version 1.0 of the model contains a baseline inventory for the OPMD officer corps as of the last day of FY 1993. The OPICC User Manual describes how updated or different inventories may be constructed and loaded into the model. The model will work

[26]Version 1.0 tracks only initial obligation, although the obligation dimension (0-5 years) is explicitly maintained throughout the entire inventory matrix.

properly with any sub-population for which an inventory and starting rates can be generated in the proper format, provided that the sub-population does not have significant external interaction with an excluded group. OPICC will not, for example, allow the user to construct a set of branch-specific populations and predict cross-branch interactions.

At the beginning of each projection year, OPICC reads the appropriate policy scenario variables, the underlying retention rates, and the begin-year inventory (the end-year inventory for the previous year). Next, these begin inventories are "aged" by advancing both YOS and TIG by one and by decreasing remaining obligation by one (if greater than zero). High-year tenure rules are applied at this time; officers who are already retirement-eligible are counted as such, while those who are not are counted as involuntary losses.

OPICC uses the ACOL methodology to modify the base retention rates. These modified rates reflect the predicted impact of the policy scenario which the user has specified (e.g., changes in pay, unemployment, inflation). The modified rates are applied to the aged inventory to estimate voluntary losses. The voluntary losses are subtracted from the inventory.

The resulting matrix of "stayers" is then promoted according to the promotion rules stated in the policy scenario. The default rules in OPICC identify a promotion zone defined by TIG for each grade. It then uses user-defined selection rates to determine the number of promotions (selection rate * inventory in zone). Under alternative promotion methods, the number of promotees is determined either by a user-supplied fixed number or by the number of vacancies in the target grade. For all promotion methods, then, OPICC applies a set of *distribution* rules to determine which officers are promoted. The user specifies the percentage of total promotions to be taken from in-zone, above-zone and below-zone populations. Officers who are promoted are moved to the corresponding YOS/obligation cell at the target grade; all promotions are moved to the first TIG category.

After promotions, new officers are accessed. The user specifies the number of new officers by source of commission (Academy, ROTC and OCS). These accessions are added to YOS 0, Grade O1, TIG 0 for that projection year. They are spread across the initial obligation dimension according to the specified distribution rate.[27] The number of accessions will always equal the user-specified number, except when the user has selected the

[27]For non-OPMD populations (if included in later versions of OPICC), it may be necessary to relax these restrictions to allow accessions at YOS > 1 and Grade > O1.

"REDUCE ACCESSIONS" method to reach aggregate endstrength goals. If necessary, accessions may be reduced.

The final change to inventory is to calculate and remove involuntary losses other than those resulting from high-year tenure rules. The user specifies a number of involuntary separations by grade and projection year. If the projected inventory exceeds the target goal and the user has selected "FORCED LOSSES" to meet endstrength goals, involuntary losses may be larger.

Computing New Retention Rates (ACOL Methodology)

The heart of the model's predictive capability is a set of econometric parameters with which OPICC can modify retention rates to reflect changes in relative military pay and in external economic conditions. The econometric estimation provided two key parameters: the ACOL coefficient and the unemployment coefficient. OPICC uses these in the following manner.

First, assume that the set of economic and policy conditions observed for the base year produced both the end-year inventory and the retention rates observed for the base year. OPICC calculates the Annualized Cost of Leaving (ACOL) variable associated with each inventory cell for the baseline pay and economic data. Changes in retention rates are then calculated based on *changes* in the ACOL variable and *changes* in the unemployment rate.

A simple example illustrates. Suppose officers in YOS j exhibited a retention rate in the base year of 0.90 and that the calculated ACOL value for those officers is $ACOL_0$. Assume the base unemployment rate is 6.0 percent. Another way to look at the retention rate is as the probability that an individual in that inventory cell will stay:

$$P_{j,0} = 0.9 \, .$$

In the structure of the retention equations estimated for this model, these probabilities follow the cumulative normal distribution (Φ):

$$P_{j,0} = \Phi(Z_{j,0}) = 0.9 \, .$$

For the base retention rates, OPICC solves for the associated "Z" value (probit index). In this example, Z ≈ 1.2816.

For projection year *i*, OPICC calculates the new ACOL values for each inventory cell. It subtracts the base ACOL value from the new value to get the net change in the pay variable resulting from all of the policy scenario information provided by the user. OPICC also calculates the change in the national unemployment

rate. These changes are multiplied by the appropriate econometric parameters (β_A and β_U) and added to the base Z value to produce the new predicted retention rate:

$$P_{j,i} = \Phi\left[Z_{j,0} + \beta_A(ACOL_{j,i} - ACOL_{j,0}) + \beta_U(U_i - U_0)\right].$$

The OPICC User Manual discusses the options for affecting the pay (ACOL) variable, including

- Periodic civilian and military nominal pay raises
- Elements of military pay, including retention bonuses and separation pays
- Changes in inflation rates
- Retirement pay rules

The user does not calculate ACOL values for the model. OPICC calculates them using a method consistent with the way they were generated for the underlying econometric analysis.

OPICC Model Validation

Since OPICC is intended as a policy tool to predict the retention and force-structure impacts of policy actions, it was validated against historical data to determine its accuracy, consistency and reliability. Two validation tests were conducted. First, the model was used to predict end-FY 1992 inventories and FY 1992 loss behavior starting from end-FY91 baseline information, based on policy actions and economic conditions in place during that fiscal year. Second, OPICC was loaded with baseline data from the end of FY 1979 and used to project inventory for FY 1980 through FY 1985.

The FY 1992 validation was a crucial test. It involved a number of voluntary and involuntary loss programs as the Army adjusted the size of its officer force. The largest program was the VSI/SSB voluntary exit program, which was accepted by 4,842 officers in FY 1992. In addition, however, over 1,300 officers accepted Voluntary Early Release, in which they were able to leave the Army with remaining obligations. An additional 2,763 officers accepted Voluntary Early Retirement, while 1,654 left as a result of Selective Early Retirement Boards. Finally, 244 O4s were separated through a Reduction in Force (RIF).

The impact of these programs was likely larger than the numbers indicate, however. While a very small number of officers were involuntarily RIFed, it is likely that a sizable number of officers weighed the probability of a RIF heavily in their "voluntary" stay-leave decisions. The validation scenario included baseline FY 1991 continuation rates and end-FY 1991 officer inventories; pay and economic information for FY 1992

(including VSI/SSB); and forced losses to simulate the impact of the involuntary separation programs. Table 13 summarizes the voluntary and involuntary loss programs that were simulated in the FY 1992 validation run.

Table 13

FY 1992 Voluntary and Involuntary Loss Programs

Voluntary Programs			
Voluntary Early Release and Retirement Program (VERRP)—officers with either 3-6 or 20 or more YOS			1,334
VSI/SSB	YG82	O3	692
	YG78	O4	335
	YG79	O4	232
	YG80	One-time non-select to O4	795
	YG81	One-time non-select to O4	735
	----	One-time non-select to O3	14
	----	WO One-time non-select for prom	14
	YOS 6-19		2,005
	Total		4,842
Voluntary Early Retirement		O6	692
		O5	1,911
		O4	143
		O3	17
	Total		2,763
Involuntary Programs			
Selective Early Retirement Boards (SERB)		O6	315
		O5	1,149
		O4	182
		O3	8
	Total		1,654

Table 14 summarizes the results of the validation run.

Table 14
FY 1992 Validation Results

YOS	Begin-Year Strength	Predicted Losses	Pred. End-strength	Actual Losses	Actual End-strength	Delta
0	3,678	0	3,614	0	3,614	0
1	4,481	0	3,678	82	3,596	82
2	5,346	28	4,453	222	4,259	194
3	4,108	1,074	4,271	1,109	4,237	34
4	3,219	1,020	3,087	1,065	3,043	44
5	3,416	162	3,057	439	2,780	277
6	3,353	336	3,080	415	3,001	79
7	3,346	188	3,165	380	2,973	192
8	3,137	286	3,060	298	3,048	12
9	2,752	162	2,975	291	2,846	129
10	3,003	141	2,611	314	2,438	173
11	2,812	161	2,842	367	2,636	206
12	2,054	120	2,692	487	2,325	367
13	1,997	141	1,913	129	1,925	-12
14	1,925	210	1,787	198	1,799	-12
15	1,830	64	1,861	77	1,848	13
16	1,520	77	1,753	59	1,771	-18
17	1,564	73	1,447	69	1,451	-4
18	1,695	89	1,474	57	1,507	-33
19	1,575	120	1,574	118	1,577	-3
20	1,286	787	788	546	1,029	-241
21	1,424	365	921	383	903	18
22	1,109	457	966	406	1,018	-52
23	856	262	847	281	828	19
24	843	227	629	212	644	-15
25	525	280	550	260	583	-33
26	384	248	258	186	339	-81
27	372	132	225	141	243	-18
28	234	182	148	167	205	-57
29	211	36	144	50	184	-40

OPICC appears to predict early retention patterns reasonably accurately. The largest divergence between predicted and actual strength occurred in the range YOS 6 to YOS 12, which encompasses

many of the year groups eligible for the VSI/SSB program. In these cases it appears that OPICC underpredicts take rates for the voluntary incentives. As mentioned above, however, this may be due, in part, to the impact of RIF threats (since OPICC is designed to measure purely voluntary separation behavior). YOS 20 losses were actually much lower than predicted. The validation scenario included about 240 SERB involuntary losses which were removed from this cohort before allowing for voluntary loss behavior. It is possible that a large number of the losses identified as SERBs would have left at any rate. Indeed, this overprediction occurs in other retirement-eligible YOS groups for which a large number of SERBs were added. Figures 3 and 4 display the inventory and retention rate results graphically.

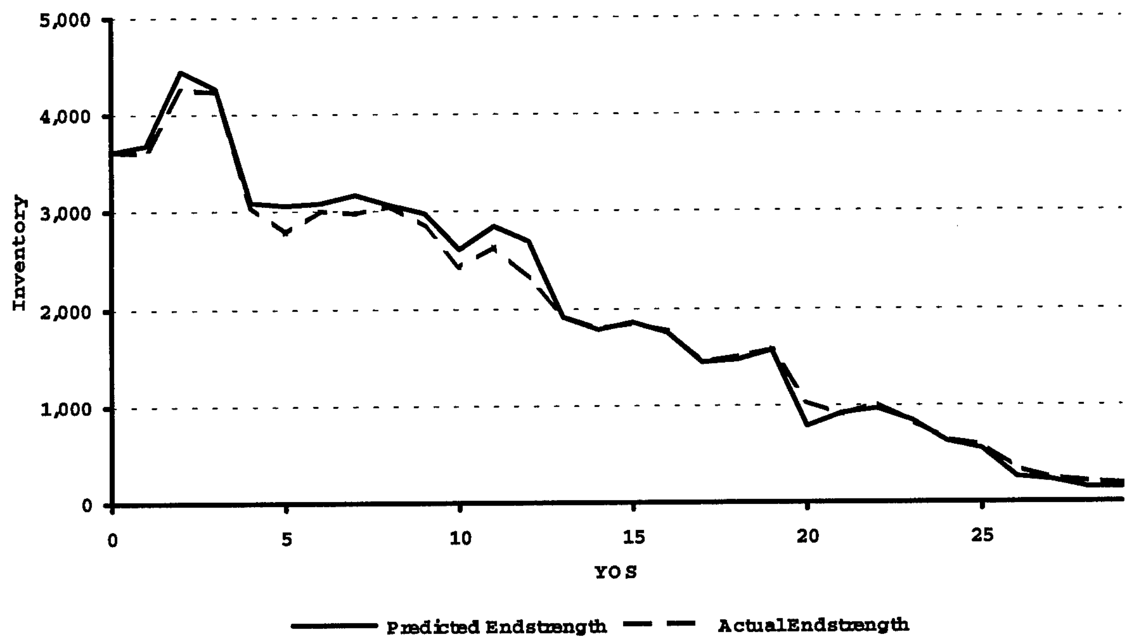

Figure 3: FY92 Predicted vs. Actual Inventory

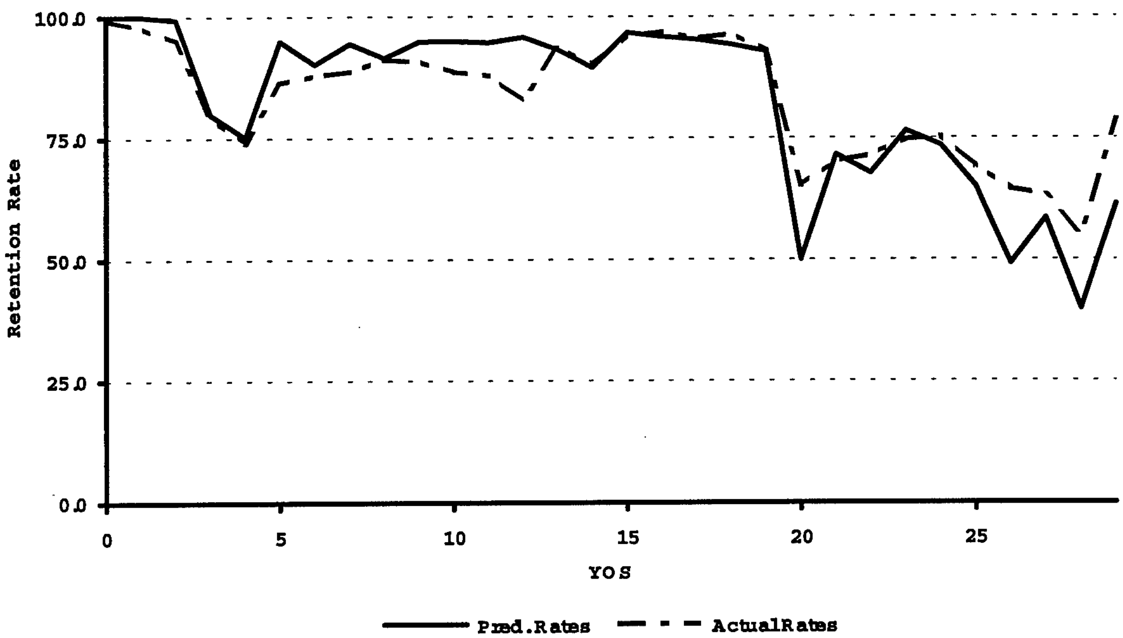

Figure 4: FY92 Predicted vs. Actual Retention Rates

The second validation test used a FY 1979 baseline to project inventories for FY 1980 through FY 1985. This period corresponded to a dramatic increase in the size of the military, as well as two substantial increases in military pay levels in 1981 and 1982. Actual military and CPS wage increases, as well as historical information on inflation and unemployment rates, were included in the run scenario. Figures 5 through 10 show the predicted versus actual inventory for each year in the validation. These results show that the model continues to predict fairly closely the retention patterns actually observed in the historical data.

The greatest discrepancy occurs in the earliest YOS cells, a problem that increases throughout the projection period. One possible source of inaccuracy could be misspecification of initial obligation. The historical data available for the validation did not include detailed information on the distribution of initial obligations in each accessing cohort, and instead relied on OPICC's default distributions. Thus, the percentage of each cohort able to make voluntary retention decisions may not have been correct. Across other ranges of the officer force, the predictions appear to have followed actual changes in retention patterns.

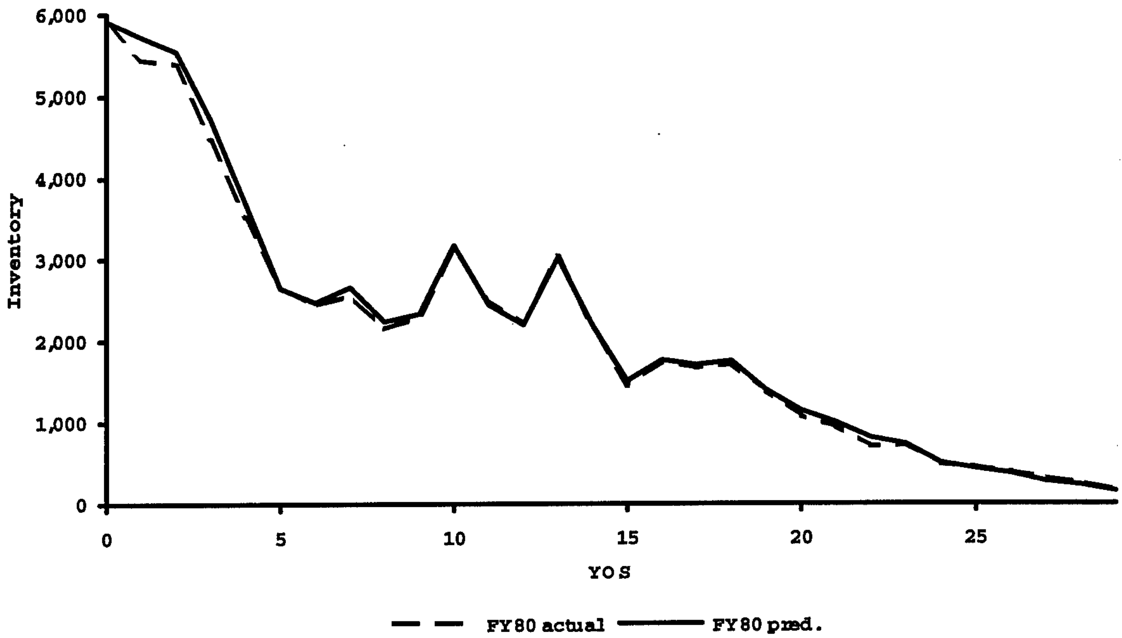

Figure 5: FY80 Predicted vs. Actual Inventory

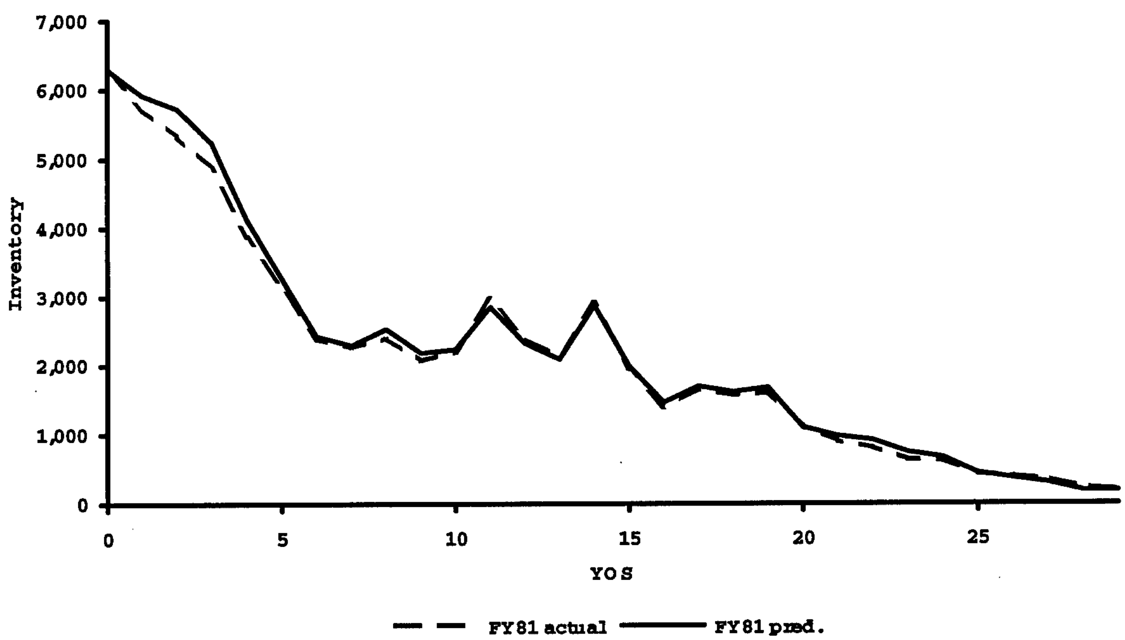

Figure 6: FY81 Predicted vs. Actual Inventory

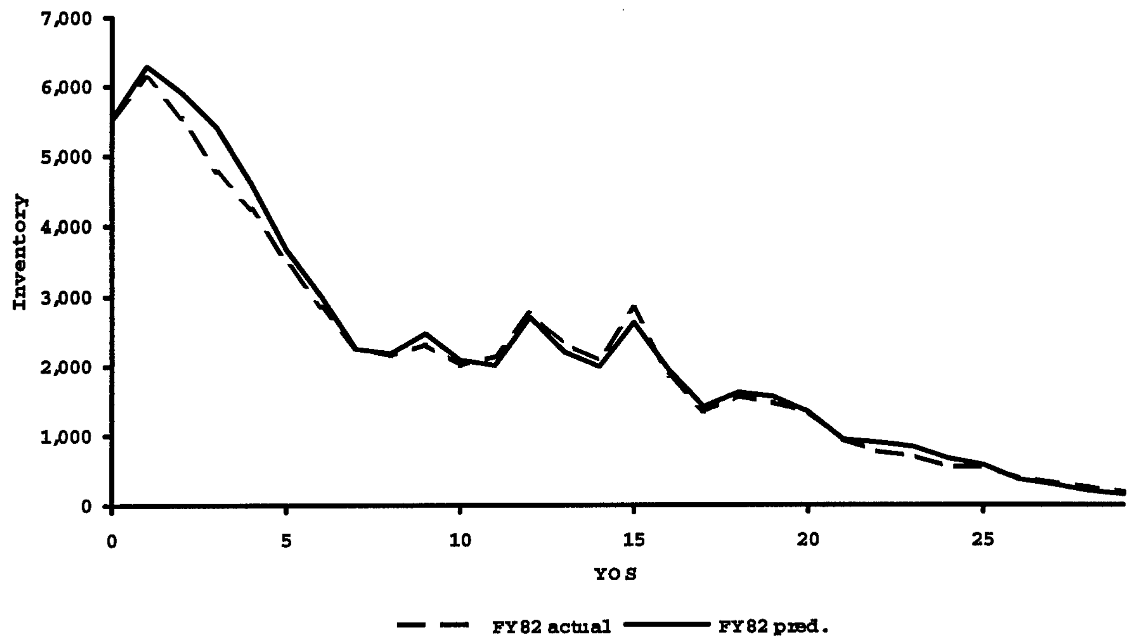

Figure 7: FY82 Predicted vs. Actual Inventory

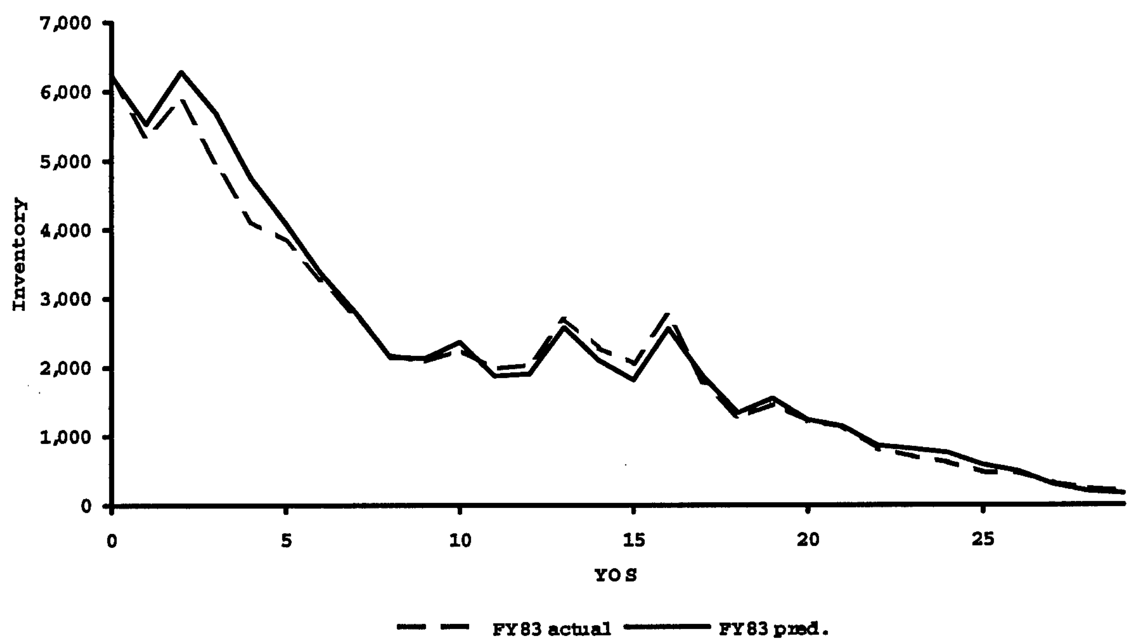

Figure 8: FY83 Predicted vs. Actual Inventory

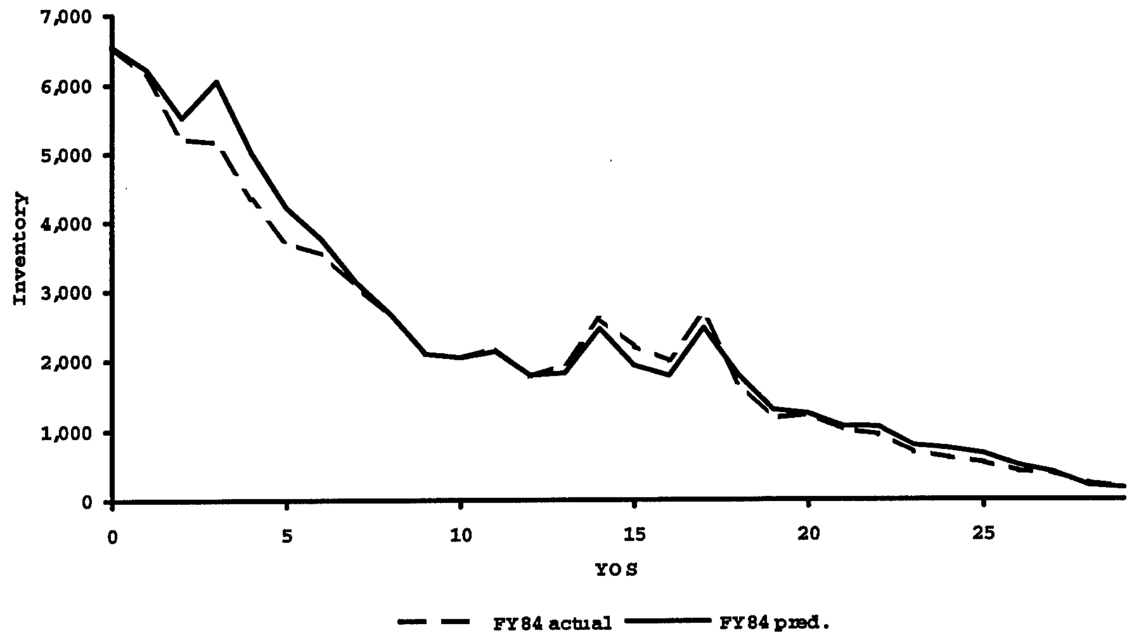

Figure 9: FY84 Predicted vs. Actual Inventory

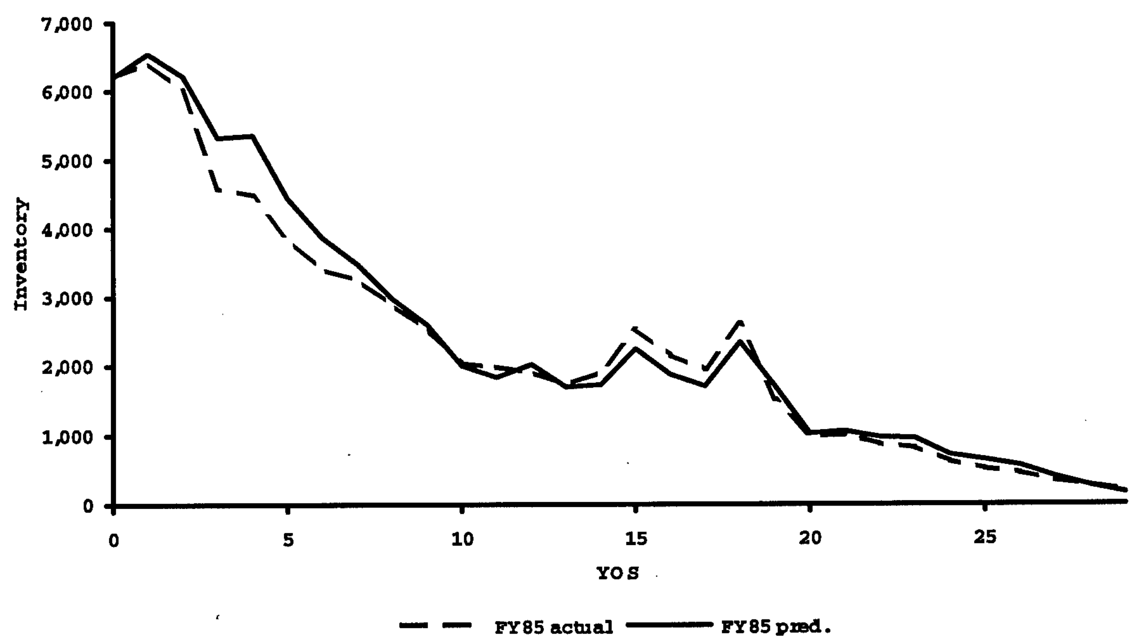

Figure 10: FY85 Predicted vs. Actual Inventory

CONCLUSIONS

This research provides new estimates of the relationship between relative military and civilian pay levels and the probability that Army officers would stay on active duty. It is based on previous retention research and a utility-maximization model of voluntary occupational choice. OPMD-branch Army officers demonstrated a significant positive (albeit small) relationship between military pay and retention—increases in the pecuniary returns to Army service increased the probability that officers would stay.

Several alternatives were tested before the final ACOL specification for the OPICC model was selected. A pooled probit model was tested. The pooled probit results tended to underpredict retention. The decreased predictive accuracy of the pooled probit can be attributed to its failure to incorporate cross-period correlation of individual stay/leave decisions.

The major advantage of the panel probit (ACOL-2) framework is that it *does* provide a structure that explicitly controls for the effects of unobserved heterogeneity within a cohort of officers as it ages past successive decision points. As in previous research, this study demonstrated the presence of a strong correlation between successive retention decisions.

Within the panel probit context, the "basic" specification (which produced the most accurate projections) was compared against one which incorporated branch specific effects. Branch effects were only sporadically significant and did not increase the model's explanatory power. In fact the equation that includes branch and ACOL interaction effects exhibited the largest discrepancy between predicted and observed retention.

The non-branch specific ACOL-2, then, forms the behavioral component of the prototype OPICC model. The "basic" retention equation selected also includes other statistically significant explanatory variables. Demographic indicators, dependent status, and the correlation coefficient (rho) each increases the model's predictive capacity. Unemployment is also included, but it is not significant at the .05 level.

The structure of the OPICC prototype consists of a basic inventory ager which adjusts for user-specified simulations using the econometric relationships of the ACOL-2 model. This allows OPICC to calculate retention rates based on reliable econometric parameters. Inventory projections are tied to internal policy actions which affect base or bonus pay, retirement benefits, and promotion rates as well as forecasts of external conditions such as the inflation and unemployment rates. Finally, the model controls for involuntary separations which occur during an

officer's first fifteen years.

Further research will allow the model to add non-OPMD branches as well as a cost module that can integrate data from the Army Manpower Cost System (AMCOS) database. This will allow OPICC to estimate the budget impact of proposed policy actions. Other elements of OPICC will benefit from quantitative research as well. This research did not address other important aspects of officer careers, including the effects of arduous and OCONUS duty and the behavior of retirement-eligible officers. Also, further research on civilian earnings opportunities may yield additional insights into the economic alternatives faced by Army officers.

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